ESD-TR-65-12

A TECHNIQUE FOR ANALYSIS
AT 10 mb

Abraham M. Pavlowitz
Bernard J. Erickson

September 1965

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FOREWORD

System 433L; project 2.0; task 2.1. This TR has been prepared for United Aircraft Corporation, East Hartford, Conn., under Subcontract no. 15107 to Contract no. AF19(628)-3437, by The Travelers Research Center, Inc., 250 Constitution Plaza, Hartford, Conn. The Research Center's publication number is 7463-175. Robert L. Houghten, Lt. Colonel, USAF, is Acting System Program Director. This report covers the period 1 January, 1965—31 July, 1965, and was submitted for approval on 8 September, 1965.

ABSTRACT

Two sets of vertical extrapolation equations were derived to specify initial-guess fields of 10-mb heights and temperatures using a five-year data sample.

Both past (t_{-24}) and present (t_0) data were considered as specifiers in the first set of equations. Only present (t_0) data were used as specifiers in the second set of equations. Both sets of equations showed stability when tested on independent data. Further, verification statistics showed that the results from the independent data were similar to those from the dependent data.

Both sets of equations were then compared by incorporating them into a modified successive approximation technique to produce initial-guess fields. These initial-guess fields were similar. An experiment comparing the two sets of equations with equations derived by the U.S. Weather Bureau showed that the TRC equations gave lower specification errors.

This technical report includes (or supersedes) information previously published under TM 11-7459-138.

REVIEW AND APPROVAL

Publication of this technical report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

Robert L. Houghten

Robert L. Houghten
Lt. Colonel, USAF
Acting System Program Director

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SECTION I

INTRODUCTION

An earlier report by Rahn and Spiegler [6] described a technique for objectively analyzing 10-mb heights and temperatures using vertical extrapolation equations for generating initial-guess fields.

These extrapolation equations had two shortcomings. First, a limited amount of data was available for their development, permitting only a gross geographic and seasonal stratification of the developmental sample. Second, as demonstrated by Snellman [7], repeated application of the equations to a series of height and temperature analyses in "no-data" regions led to a systematic increase in specification errors.

A larger (five-year) data sample has become available since the development of the earlier extrapolation equations, permitting the design of experiments to overcome these two shortcomings.

In this study, two sets of vertical extrapolation equations were derived using the five-year data sample. The first set used data at t_0 and t_{-24} (as did the earlier study) as possible specifiers of 10-mb heights and temperatures. The second set used data at only t_0 as possible specifiers. Each set of extrapolation equations was then used to generate initial-guess fields of 10-mb heights and temperatures using a modified version of the 500–30 mb analysis build-up procedure [8].

It should be noted that there are two major experiments being described. The first is the development of the vertical regression equations, for which statistics are presented that describe the accuracy of these equations when applied to independent station data. The second is the use of these equations in a build-up procedure; the statistics presented describe the accuracy of the extrapolation equations when applied to grid-point data.

The method used to develop the vertical regression equations is presented in Section II. The application of the equations in the analysis procedure is presented in Section III. Section IV contains the results of the experiments, and Section V presents our conclusions.

SECTION II

DEVELOPMENT OF THE VERTICAL EXTRAPOLATION EQUATIONS

1. Data

The data used for the derivation of the 30—10 mb vertical extrapolation equations comprised sixty months (May 1958–April 1963) of Northern Hemisphere rawinsonde/radiosonde observations. The data were edited, checked, and corrected for solar radiation errors.

2. Stratification of Data

An examination of the stratospheric map series, published by the U.S. Weather Bureau [11], reveals that there are predominant circulations in the stratosphere that exist for certain periods of time (e.g., the anticyclone summer circulations over the North Pole, and the easterlies over the Northern Hemisphere which normally exist from June until about mid-August when the transition to the fall circulation begins).

Because the data sample is sufficiently large, it was decided that stratification of the data based on predominant circulation features was desirable because it would produce more useful extrapolation equations. The categories resulting from this stratification are termed "regimes." Table I defines these regimes. For each regime, all five years of the months included in that regime are used (e.g., Regime 2 comprises five months of March data — one month for each year of the five-year sample).

Because of the well-known gradients of temperatures and heights at stratospheric levels from equator to pole over the Northern Hemisphere, it was necessary to further stratify the data into "bands" (see Fig. 1 and Table II). The band stratification described here resulted from technical discussions with personnel of the U.S. Weather Bureau's Atmospheric Analysis Laboratory, Upper Atmospheric Branch. They have had extensive experience in analyzing and examining stratospheric charts, and although the band stratification may be considered arbitrary, it is based upon a realistic assessment of what will likely provide the optimum regression equations for extrapolation to 10-mb. To insure against discontinuities between bands, an overlap procedure was used (e.g., a few stations adjacent to the band boundaries were used as part of the data in generating the equations for a given band). The band stratification was limited to those areas for which data were available. There were eight bands generated for each regime.

TABLE I
REGIMES FOR WHICH EQUATIONS WERE DERIVED

Regime	Months
1	December—January, February*
1(a)	January 15—February 5, 1963†
2	March
3	April
4	May
5	June, July, August (1—15)
6	August (16—31), September
7	October, November

*Except January 15—February 5, 1963 data

†Explosive warming regime

The band stratification for Regime 1 (Dec—Feb) differs from that for the other regimes because, during the winter months, the Aleutian anticyclone is a semi-permanent circulation feature, requiring the breakdown over North America to consist of Bands 2A and 4A (see Fig. 2). One other exception is found in Regime 1a, in which Bands 1—4 were combined because there was insufficient data in the four individual bands to generate stable equations.

During the stratification processing, ten percent of the data for each band, except Band 5 (U. S.), were withheld as independent data; five percent of the data were withheld in Band 5.

3. Screening Regression Experiments

Covariance matrix generation and screening-regression programs written by Enger and Rodante [2] were used to derive the vertical extrapolation equations for specifying 10-mb height and temperature initial-guess fields used in the analysis program.

When multiple regression equations are being developed, a problem is encountered if the number of predictors used is too large. This may lead to unstable results when the equations are applied to new samples [4]. Thus, the first step in the procedure

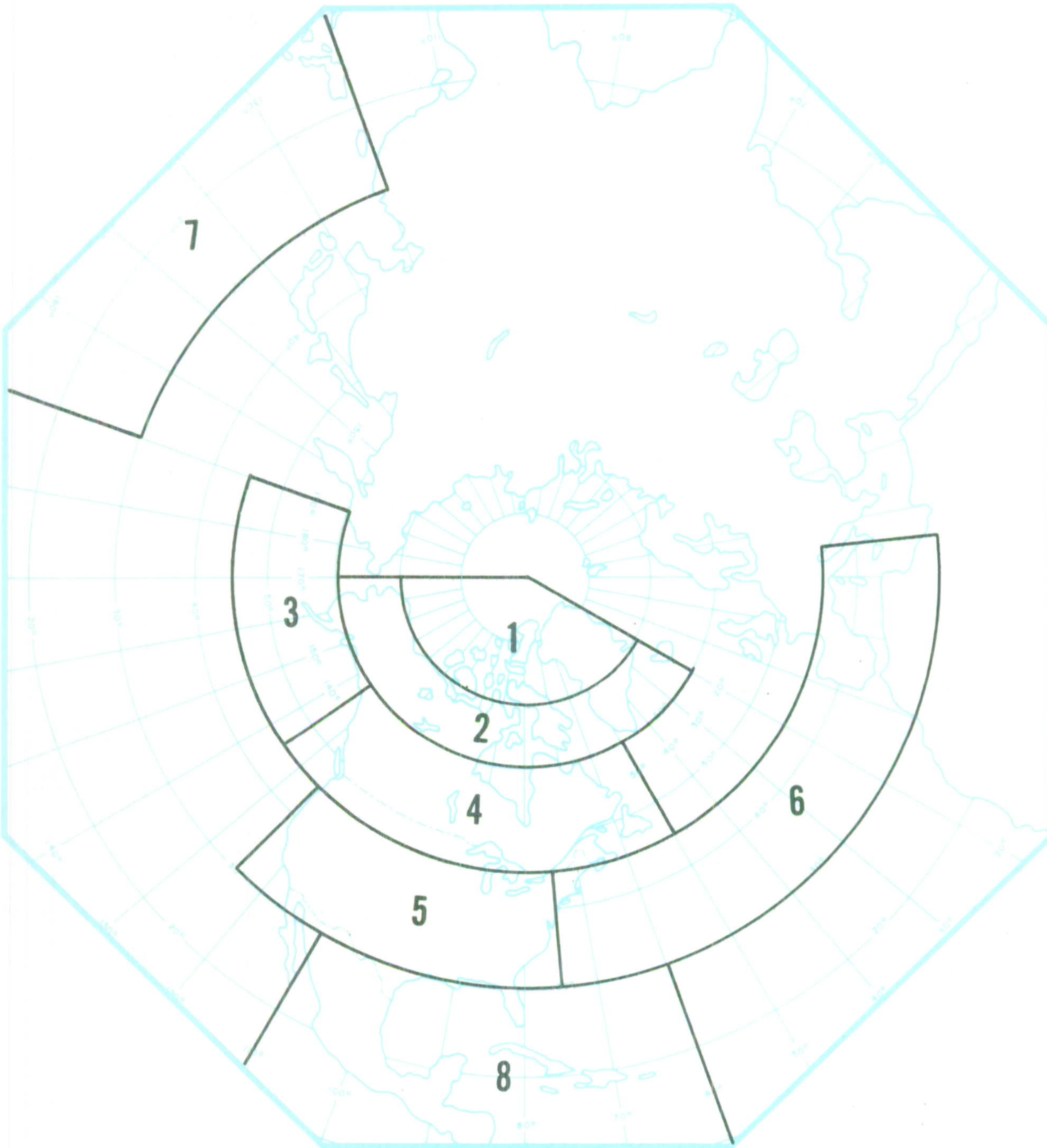

Fig. 1. Band stratification for Regimes 2-7.

TABLE II
BAND BOUNDARIES

Band	Boundaries
1	170°W – 20°W, 70°N – 90°N
2	170°W – 20°W, 60°N – 70°N
2A*	170°E – 135°W, 45°N – 70°N
3	170°E – 135°W, 45°N – 60°N
4	135°W – 50°W, 45°N – 60°N
4A*	135°W – 20°W, 45°N – 70°N
5	125°W – 75°W, 30°N – 45°N
6	75°W – 15°E, 30°N – 45°N
7	120°E – 155°W, 0° – 30°N
8	110°W – 60°W, 0° – 30°N

*Bands 2A and 4A, rather than Bands 2, 3, and 4, are used in the December–February regime.

is to consider specifiers having meteorological significance for specifying 10-mb heights and temperatures. The screening procedure further reduces the number of specifiers by accepting only those with the highest statistical significance according to a specified criterion. This method has been described by Miller [5] and is based on a paper by Bryan [1].

Using the screening procedure, two sets of extrapolation equations were derived for each band of each regime. The first set used data at t_0 and t_{-24} as possible specifiers. The second set used data at t_0 only.

The specificands, and their possible specifiers used to develop the two sets of equations for each band of each regime, are presented in Table III. The possible specifiers for the set of equations using past data were those used by Rahn and Spiegler in the earlier report [6], with one addition. The mean temperature between 30 and 10 mb at t_0 was added as a possible specifier for 10-mb heights. The purpose of including this additional specifier in the screening regression experiments is explained in the following discussion.

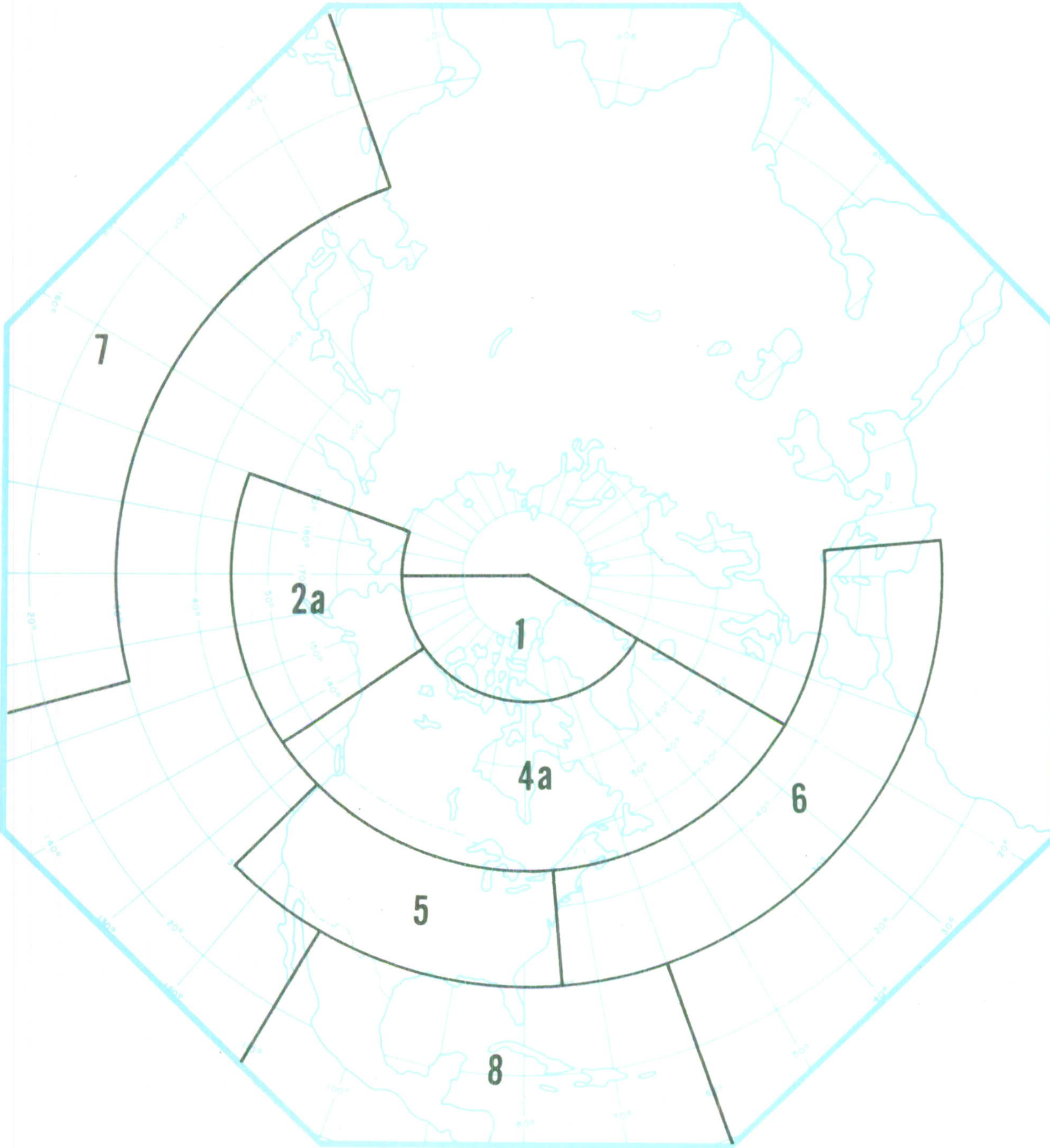

Fig. 2. Band stratification for Regime 1.

TABLE III

POSSIBLE SPECIFIERS FOR VERTICAL EXTRAPOLATION EXPERIMENTS

Specificand	Specifiers*
$Z_0(10)$	$Z_{-24}(10)$, $H_{-24}(50{-}30)$, $H_{-24}(30{-}10)$, $Z_0(30)$, $T_0(30)$, $H_0(50{-}30)$, $\overline{T}_0(30{-}10)$
$T_0(10)$	$T_{-24}(10)$, $\overline{T}_{-24}(50{-}30)$, $\overline{T}_{-24}(30{-}10)$, $Z_0(30)$, $T_0(30)$, $\overline{T}_0(50{-}30)$, $H_0(30{-}10)$

*Z = height (decafeet), T = temperature (°C), H = thickness of layer (decafeet), and $\overline{T}$ = mean temperature of layer (°C). Subscript 0 denotes observation time. Subscript -24 denotes 24 hours prior to observation time.

In the earlier study [6] the thickness of the 30- to 10-mb layer at t_0 [$H_0(30{-}10)$] was found to be a significant specifier for 10-mb temperatures. It was available as a specifier because the 10-mb height analysis was generated first and, thus, permitted the computation of $H_0(30{-}10)$. However, if the temperature analysis is performed first, the $\overline{T}_0(30{-}10)$ becomes a possible specifier to 10-mb height. It is obvious that both cannot be used.

The $\overline{T}_0(30{-}10)$ was added as a possible specifier in an experiment to determine whether it is more advantageous to perform the height analysis prior to the temperature analysis or vice-versa. The question of preference is answered by determining whether $H_0(30{-}10)$ is a better specifier of 10-mb temperatures than is $\overline{T}_0$ (30–10) of 10-mb heights.

The vertical extrapolation equations developed by the series of screening regression experiments are used in the modified 500–30 mb analysis technique to generate 10-mb height and temperature initial-guess fields.

SECTION III

ANALYSIS TECHNIQUE

This section discusses the analysis technique used to generate 10-mb fields of height and temperature. The vertical extrapolation equations are used in the analysis procedure to provide the initial-guess fields necessary for the operation of this program. It should be noted that the data sample used to test the analysis technique is considerably smaller than the five-year data sample used to generate extrapolation equations.

4. Height and Temperature Analyses

The 10-mb height and temperature analyses are produced using a modified version of the 500- to 30-mb build-up procedure described in an early report [8]. The 500–30-mb technique uses vertical extrapolation equations to provide an initial-guess field for the level being analyzed. The initial-guess field is then corrected with observed data (t_0) for that level using the successive approximation analysis technique (SAT) [8]. The same technique is used in the 10-mb analysis procedure.

Because of the small number of stations that report 10-mb data, the successive approximation analysis technique was modified so that past data (12- to 48-hr prior to analysis time) could be used to correct the initial guess. The weighting of past data relative to present data in the correction of the initial guess is a function of both the time of the observation and the density of reports in the area. The weighted value of a given past-data station is applied to the correction term in the SAT analysis.

The effect on the analysis of varying the weighting factors for past data was tested in an earlier report [6], but the results were inconclusive because of the small data sample (00Z February 3–00Z February 5, 1962) used in the analysis program. Because the data sample used in this study (00Z February 3–12Z February 7, 1962) is merely two and one-half days larger than the earlier sample, only one set of weighting factors was used.

Table IV lists the weighting factors as functions of data density in the vicinity of each station, and the number of earlier observations at each station. (Earlier observations refer to the order of listing of station data on tape; t_0 reports are listed first; t_{-12}, t_{-24}, t_{-36}, and t_{-48} are next in order, respectively. Therefore, when selecting

TABLE IV

WEIGHTING FACTORS USED IN ANALYSIS TECHNIQUE

(based on station density and number of past-data reports)

Time	Observational density			Conditions
	Low	Medium	High	
t_0	1.0	1.0	1.0	—
t_{-12}	1.0	0.9	0.7	0*
	0.4	0.3	0.2	1*
t_{-24}	0.7	0.5	0.4	0†
	0.3	0.2	0.1	1†
	0.1	0.1	0.0	2†
t_{-36}	0.4	0.3	0.2	0†
	0.3	0.2	0.1	1†
	0.2	0.2	0.1	2†
	0.1	0.1	0.0	3†
t_{-48}	0.3	0.2	0.1	0†
	0.2	0.1	0.1	1†
	0.1	0.1	0.1	2†
	0.1	0.1	0.1	3†
	0.0	0.0	0.0	4†

*Number of t_0 reports at station.

†Number of earlier reports at station.

a weighting factor for a t_{-24} report, the earlier observations are the t_{-12} and t_0 reports.)

In the earlier 10-mb analysis study [6], a method was developed to determine the necessary observational density requirements for adequate analyses of particular areas. The Northern Hemisphere was divided into six areas as shown in Fig. 3. The number of radiosonde stations in each area was determined and observations at a specified percent of these were required as input to the analysis program (see Table V). If the observational density requirements were not met, "off-time" observations were

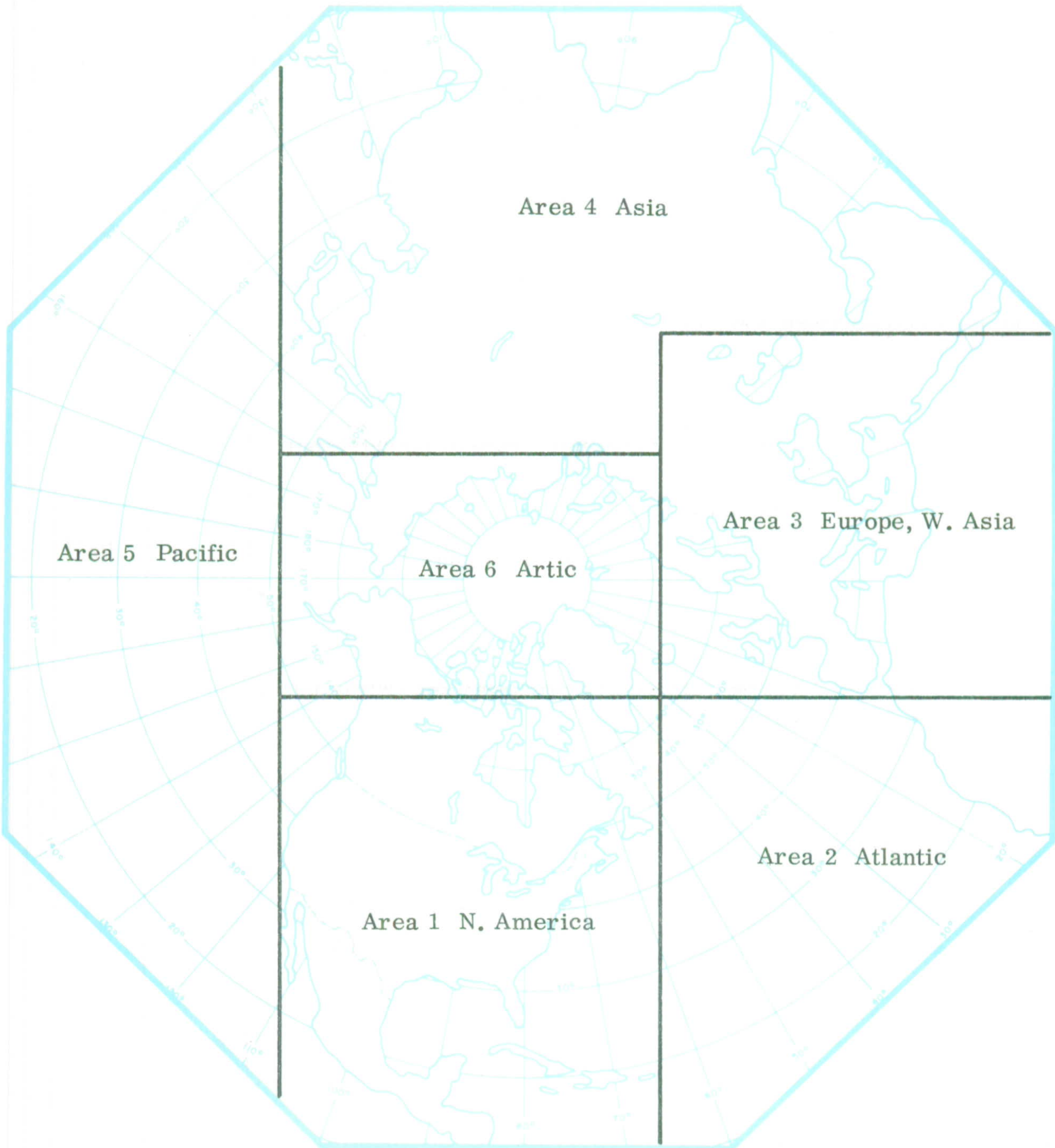

Fig. 3. Areas over northern hemisphere for which minimum number of observations are necessary in 10-mb analysis.

TABLE V

SPECIFIED MINIMUM NUMBER OF STATIONS NECESSARY FOR 10-MB ANALYSIS OVER VARIOUS AREAS OF THE HEMISPHERE

Area	No. of stations
1	60
2	8
3	20
4	11
5	8
6	18

included in the SAT analysis by the following procedure. If the t_0 observations are below a threshold limit, t_{-12} observations are added; if this augmentation does not bring the observational density above the threshold limit, t_{-24} observations are then included. The decision as to whether or not t_{-36} and t_{-48} observations will be included in the analysis is made in the same manner. In the sample used in this study, the above rules required the use of all four sets of off-time observations for adequate analyses.

SECTION IV

SCREENING REGRESSION AND ANALYSIS RESULTS

Two distinct groups of statistical results are discussed in this section. The first group relates to the derivation, and testing on independent data, of the vertical extrapolation equations. Also included in this group are the results of a comparison of the specification of 10-mb heights and temperatures produced by the TRC present-data equations with those produced with the USWB equations. The second group of statistical results relates to the testing of the TRC equations in the analysis procedure, and to the verification of the analyses using the areal-mean-error method [10].

5. Screening Regression Results

Vertical extrapolation equations were developed for all regimes and bands having sufficient data. Rms errors of the temperature equations with H(30—10) as a specifier were compared to those of the temperature equations without H(30—10) as a specifier. A similar comparison was made of the rms errors of the height equations with and without $\overline{T}$(30—10) as a specifier. Although $\overline{T}$(30—10) was significant for specifying 10-mb heights, the exclusion of H(30—10) as a specifier in the present-data equations resulted in large rms errors for the temperature equations; this was especially true for the winter-months data (see Table VI). It was decided that H(30—10) is more useful for specifying 10-mb temperature than is $\overline{T}$(30—10) for specifying 10-mb heights, and thus, height analyses should be made prior to temperature analyses.

The vertical extrapolation equations developed for each band of each regime were tested on the independent data sample. The dependent and independent statistical results are tabulated in Appendix II (where the specifiers are listed in the order of their selection). The tables have parts (a) and (b) for each regime; part (a) of each table gives the result of using both past (t_{-24}) and present (t_0) data as specifiers[1], and part (b) gives the results of using only present data as specifiers.

It is evident that the equations using both past and present data have the lower rms errors on both the dependent and independent data sample for 10-mb heights. When applying the equations in the analysis technique, one should use the past and present data

[1] There are some bands in which no past-data specifiers were selected as significant predictors.

TABLE VI

COMPARISON OF rms ERRORS WITH (Exp. 1) AND WITHOUT (Exp. 2) $\overline{T}(30-10)$ AS A HEIGHT SPECIFIER AND WITH (Exp. 3) AND WITHOUT (Exp. 4) H(30—10) AS A TEMPERATURE SPECIFIER (present data, dependent sample)

(a) December—February

Band	Exp. 1 (ft)	Exp. 2 (ft)	Exp. 3 (°C)	Exp. 4 (°C)
1	115	293	2.0	4.8
2A	132	296	2.5	5.4
4	136	322	2.7	5.7
5	139	282	3.0	4.8
6	165	336	2.9	5.6
7	172	227	2.8	3.8
8	91	205	2.7	4.2

(b) June—1/2 August

Band	Exp. 1 (ft)	Exp. 2 (ft)	Exp. 3 (°C)	Exp. 4 (°C)
1	107	159	1.6	2.6
2	106	160	1.6	2.6
3	81	141	1.6	2.6
4	107	151	1.8	2.6
5	134	165	1.9	2.6
6	90	132	1.7	2.5
7	166	193	2.3	2.8
8	141	168	2.2	2.7

equations as specifiers for those areas where previous (t_{-24}) observations are available. The temperature rms errors are about the same for both sets of TRC equations. The reason for their similarity is that H_0(30—10) was usually selected as the first predictor in both sets of equations, and accounted for a significant part of the variance of the 10-mb temperature.

In general, both sets of equations for specifying 10-mb heights and temperatures are relatively stable, with the independent-data errors close to those of the dependent data. The largest difference between dependent- and independent data errors is in the 1963 warming regime (see Table XXI in Appendix II). The warming first became apparent on January 15 and lasted through approximately February 5 [3]. Because the change-over is gradual, the data used to develop the equations reflect the conditions both before and after the warming; this is the probable cause of the high rms errors and standard deviations.

Vertical extrapolation equations developed by the U. S. Weather Bureau were also tested on the independent data sample (present-data only) for Regimes 1, 3, 4, 5, and 7. The Weather Bureau developed separate equations for January—February and for December, and each set was tested on the independent data for Regime 1.

The Weather Bureau equations use 30-mb heights and temperatures at t_0 for specifying 10-mb heights, and 30-mb temperatures at t_0 for specifying 10-mb temperatures. The results are presented in Table VII. A comparison of Table VII with Tables XIV(b), XVI(b), XVII(b), and XX(b) (in Appendix II) shows that the height and temperature rms errors obtained by using our (TRC) equations are generally lower than those from the Weather Bureau equations. To determine if the differences in the errors were significant, the height and temperature forecasts produced by the TRC and USWB equations were compared by means of the Student "t" test [12].

The results of comparing TRC and USWB specifications of 10-mb heights and temperatures are presented in Tables VIII through XI. It can be seen from the tables that the temperature specifications made with the TRC equations are significantly better than those made with USWB equations. The 10-mb height errors of the TRC equations are, in general, significantly lower, although there are some cases in which both TRC and USWB equations are equally good. One obvious reason why the TRC temperature equations give better results is that they use H(30—10) as a specifier.

The regression equations developed with past and present data, and present data only, are given in Appendix I. The format of the equations is such that only heights and temperatures are needed as input (e.g., thickness is converted to a difference of two heights).

TABLE VII

RESULTS USING USWB EQUATIONS ON INDEPENDENT PRESENT DATA

(a) December, January, February

Band	Specificand	Rms error	
		December	January–February
1	$Z_0(10)$	321 ft	337 ft
	$T_0(10)$	5.6°C	5.9°C
3*	$Z_0(10)$	376 ft	477 ft
	$T_0(10)$	6.6°C	9.0°C
4	$Z_0(10)$	324 ft	359 ft
	$T_0(10)$	6.1°C	6.5°C
5	$Z_0(10)$	328 ft	299 ft
	$T_0(10)$	6.0°C	5.4°C
6	$Z_0(10)$	396 ft	355 ft
	$T_0(10)$	7.2°C	6.5°C
7	$Z_0(10)$	243 ft	243 ft
	$T_0(10)$	4.1°C	4.0°C
8	$Z_0(10)$	275 ft	270 ft
	$T_0(10)$	4.8°C	4.7°C

*Used on independent data from TRC Band 2A.

TABLE VII

(b) April, May, June–July, November

Band	Specificand	Rms error			
		April	May	June–July	November
1	$Z_0(10)$	278 ft	167 ft	138 ft	272 ft
	$T_0(10)$	6.0°C	3.0°C	2.6°C	5.5°C
2	$Z_0(10)$	254 ft	204 ft	159 ft	221 ft
	$T_0(10)$	4.8°C	3.9°C	3.1°C	4.1°C
3	$Z_0(10)$	249 ft	260 ft	119 ft	253 ft
	$T_0(10)$	3.8°C	3.8°C	2.2°C	4.6°C
4	$Z_0(10)$	185 ft	249 ft	201 ft	251 ft
	$T_0(10)$	3.1°C	4.3°C	3.7°C	4.5°C
5	$Z_0(10)$	280 ft	174 ft	148 ft	234 ft
	$T_0(10)$	5.0°C	3.6°C	2.3°C	3.9°C
6	$Z_0(10)$	312 ft	220 ft	147 ft	297 ft
	$T_0(10)$	5.7°C	3.0°C	2.7°C	5.2°C
7	$Z_0(10)$	225 ft	181 ft	165 ft	211 ft
	$T_0(10)$	3.5°C	3.5°C	3.1°C	3.6°C
8	$Z_0(10)$	241 ft	195 ft	187 ft	226 ft
	$T_0(10)$	3.7°C	2.5°C	2.8°C	3.8°C

TABLE VIII

STUDENT "t" COMPARISONS

December, January, February—Present Data

Band	Specificand	No. of cases	TRC better	USWB better	Student "t" value	Significance level
1	Z_0 (10)	11	8	3	1.228	—
	T_0 (10)	11	10	1	3.801	.01
3(2A)	Z_0 (10)	92	62	30	4.978	.001
	T_0 (10)	92	81	11	10.946	.001
4(4A)	Z_0 (10)	96	67	29	3.665	.001
	T_0 (10)	96	82	14	8.643	.001
5	Z_0 (10)	161	84	77	0.000	—
	T_0 (10)	161	116	45	9.022	.001
6	Z_0 (10)	72	38	34	0.685	—
	T_0 (10)	72	64	8	8.477	.001
7	Z_0 (10)	125	69	56	1.999	.05
	T_0 (10)	125	90	35	5.680	.001
8	Z_0 (10)	183	101	82	2.904	.01
	T_0 (10)	183	127	56	8.772	.001
All bands	Z_0 (10)	740	429	311	1.877	.1
	T_0 (10)	740	570	170	5.860	.001

TABLE IX
STUDENT "t" COMPARISONS
May–Present Data

Band	Specificand	No. of cases	TRC better	USWB better	Student "t" value	Significance level
1	Z_0 (10)	27	17	10	0.626	—
	T_0 (10)	27	16	11	2.146	.05
2	Z_0 (10)	22	10	12	0.096	—
	T_0 (10)	22	16	6	3.176	.01
3	Z_0 (10)	14	11	3	2.636	.05
	T_0 (10)	14	12	2	3.508	.01
4	Z_0 (10)	40	26	14	2.391	.05
	T_0 (10)	40	29	11	4.232	.001
5	Z_0 (10)	41	19	22	0.699	—
	T_0 (10)	41	32	9	5.089	.001
6	Z_0 (10)	41	26	15	1.926	.1
	T_0 (10)	41	31	10	3.359	.01
7	Z_0 (10)	64	40	24	2.680	.01
	T_0 (10)	64	41	23	3.160	.01
8	Z_0 (10)	57	32	25	0.967	—
	T_0 (10)	57	37	20	2.840	.01
All bands	Z_0 (10)	306	181	125	4.467	.001
	T_0 (10)	306	214	92	9.524	.001

TABLE X
STUDENT "t" COMPARISONS
June, July, 1/2 August (1–15)–Present Data

Band	Specificand	No. of cases	TRC better	USWB better	Student "t" value	Significance level
1	Z_0 (10)	63	40	23	3.113	.01
	T_0 (10)	63	48	15	4.792	.001
2	Z_0 (10)	55	26	29	0.210	——
	T_0 (10)	55	38	17	4.388	.001
3	Z_0 (10)	33	18	15	0.893	——
	T_0 (10)	33	23	10	3.513	.01
4	Z_0 (10)	113	69	44	3.620	.001
	T_0 (10)	113	86	27	7.387	.001
5	Z_0 (10)	103	55	48	0.994	——
	T_0 (10)	103	62	41	3.472	.001
6	Z_0 (10)	97	47	50	0.910	——
	T_0 (10)	97	66	31	4.720	.001
7	Z_0 (10)	145	90	55	3.040	.01
	T_0 (10)	145	90	55	3.797	.001
All bands	Z_0 (10)	738	421	317	1.548	——
	T_0 (10)	738	503	235	3.890	.001

TABLE XI
STUDENT "t" COMPARISONS
October, November—Present Data

Band	Specificand	No. of cases	TRC better	USWB better	Student "t" value	Significance level
1	Z_0 (10)	10	7	3	1.230	—
	T_0 (10)	10	9	1	4.110	.01
2	Z_0 (10)	53	35	18	1.342	—
	T_0 (10)	53	43	10	6.314	.001
3	Z_0 (10)	38	23	15	1.814	.1
	T_0 (10)	38	32	6	5.474	.001
4	Z_0 (10)	70	37	33	1.823	.1
	T_0 (10)	70	56	14	7.177	.001
5	Z_0 (10)	88	57	31	2.723	.01
	T_0 (10)	88	68	20	7.597	.001
6	Z_0 (10)	51	44	7	11.273	.001
	T_0 (10)	51	37	14	5.683	.001
7	Z_0 (10)	92	61	31	2.851	.01
	T_0 (10)	92	60	32	4.458	.001
8	Z_0 (10)	107	54	53	0.883	—
	T_0 (10)	107	72	35	5.326	.001
All bands	Z_0 (10)	509	318	191	3.897	.001
	T_0 (10)	509	377	132	7.507	.001

6. Analysis Results

Over many areas of the Northern Hemisphere, the height and temperature analyses at stratospheric levels are usually represented by the initial-guess fields because of the scarcity of data at these levels to correct the initial guess. For this reason, it was decided to have the analysis verification on the initial-guess rather than on the final pass. This, in effect, treats all the available stations as withheld stations. Only the temperature analyses were verified, and this was done with the areal-mean-error method [10]. Heights were not verified because they are generally regarded as relatively unreliable at stratospheric levels [9].

Two sets of 10-mb height and temperature analyses were generated for the period 00Z February 3–12Z February 7. The first set of analyses were generated using the past- and present-data vertical extrapolation equations; the second set used only the present-data equations. These equations were developed for areas where data were available, and their application over the hemisphere in this study is given in Table XII.

TABLE XII
APPLICATION OF EQUATIONS OVER THE HEMISPHERE

Band	Latitude interval	Longitude interval
1	70°N – 90°N	0 – 360°
2A	45°N – 70°N	170°E – 135°W
4A	45°N – 70°N	135°W – 170°E
5	30°N – 45°N	125°W – 75°W
5	30°N – 45°N	15°E – 140°E
6	30°N – 45°N	75°W – 15°E
6	30°N – 45°N	140°E – 125°W
7	0 – 30°N	120°E – 110°W
7	0 – 30°N	60°W – 15°W
8	0 – 30°N	110°W – 60°W
8	0 – 30°N	15°W – 120°E

The verification statistics for the initial-guess fields of 10-mb temperatures, generated from both sets of equations, are given in Table XIII. From the results presented in Table XIII, one might conclude that the initial guess produced by the present-data extrapolation equations is just as good as the initial guess produced by the past- and present-data equations. From a purely statistical point of view, this may be a correct conclusion. However, the analyses generated from each set of equations do show certain differences. Figures 4 and 5 represent the 10-mb height and temperature initial-guess fields for 00Z Feb. 3 generated using the past- and present-data equations, and only the present-data equations, respectfully.

One difference between the figures is the stronger temperature gradient over Canada in Fig. 4 (past- and present-data equations). A second difference occurs over Russia in an area north of the Caspian Sea; the height and temperature fields generated with the past- and present-data equations are significantly lower and colder (respectively) than the height and temperature fields generated with the present-data equations. If the discrepancies were due to the differences in the equations, other areas also should have been affected. Because the differences occurred in only one area (north of the Caspian Sea), it was felt that other factors were involved. An investigation of the 30-mb

TABLE XIII
10-MB TEMPERATURE ANALYSIS RMS ERRORS (INITIAL-GUESS)

Date	Time	Past and present data (°C)	Present data (°C)
Feb. 3	00Z	3.4	3.7
Feb. 3	12Z	3.7	4.0
Feb. 4	00Z	3.7	4.1
Feb. 4	12Z	3.4	3.5
Feb. 5	00Z	3.0	3.2
Feb. 5	12Z	3.0	3.1
Feb. 6	00Z	4.0	4.4
Feb. 6	12Z	4.1	4.7
Feb. 7	00Z	4.5	4.5
Feb. 7	12Z	3.9	3.9
Overall		3.7	4.0

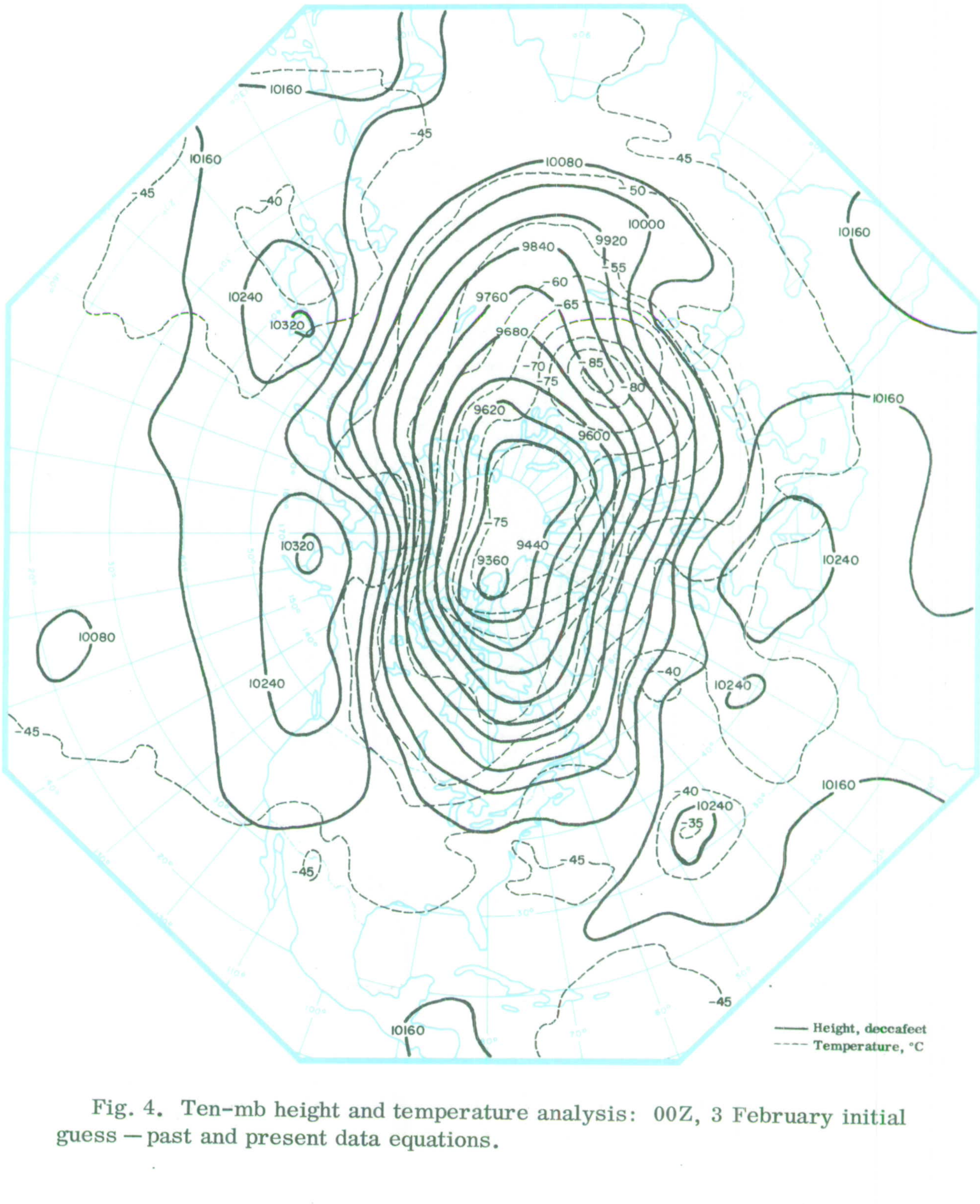

Fig. 4. Ten-mb height and temperature analysis: 00Z, 3 February initial guess — past and present data equations.

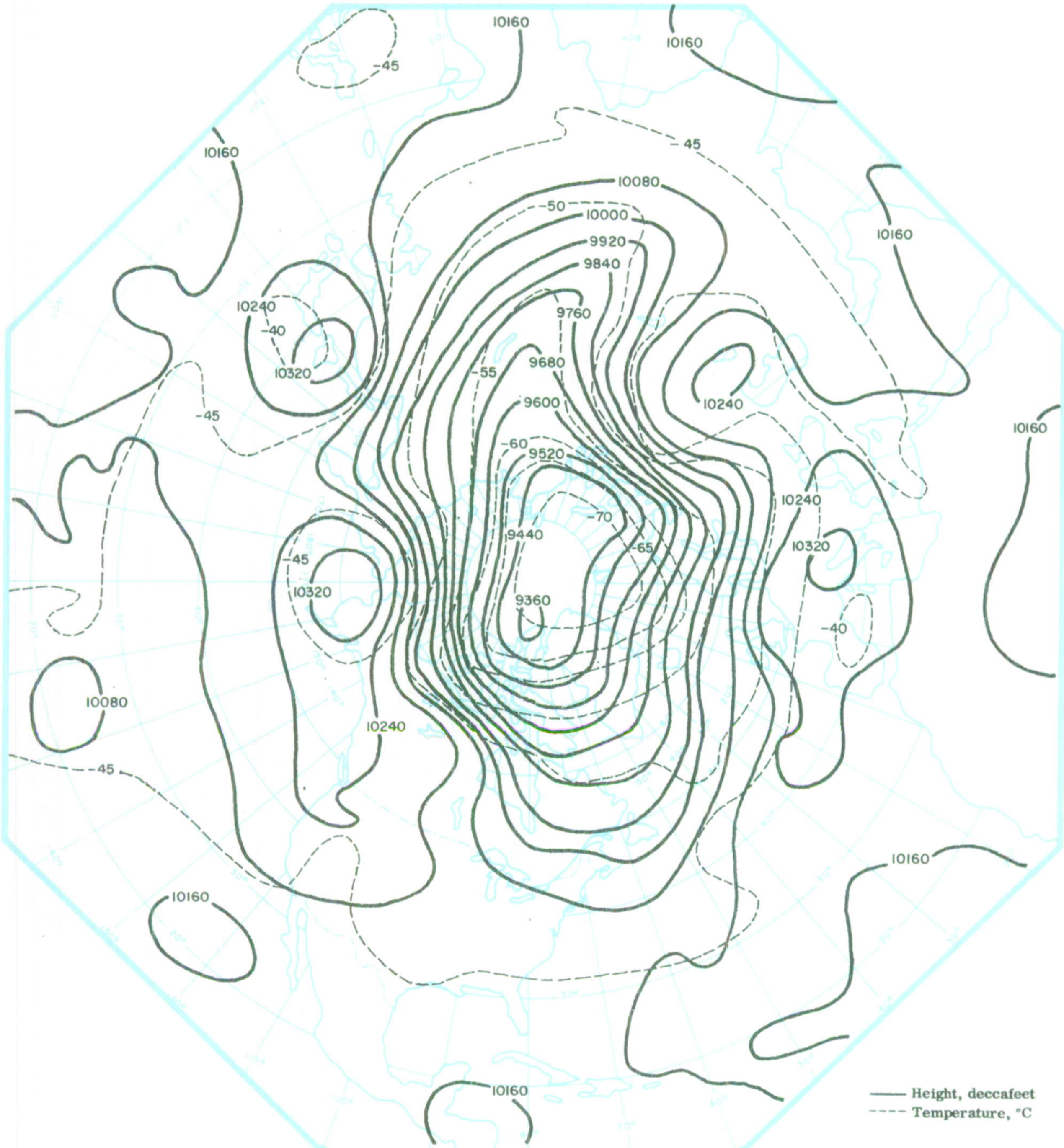

Fig. 5. Ten-mb height and temperature analysis: 00Z, 3 February initial guess — present data equations.

data revealed the answer. We found that one station (28952) had a reported 30-mb temperature of -35°C and a 30-mb height of 77190 ft. The temperature was 15°C warmer than the 50-mb temperature for that station, and the reported height was about 1000 ft lower than the average. This observation is probably in error.

The initial-guess fields of height and temperature were regenerated with both sets of equations and excluding station 28952. The results are presented in Figs. 6 and 7. A comparison of these two figures shows that the analyses are more compatible, although there are still some differences in the temperature field.

The point being made is that, in the build-up procedure, the past- and present-data equations tend to dampen the effects of erroneous data at the lower levels, especially if it is the only station (data) in the area, while the present-data equations tend to magnify these effects.

The initial-guess fields of height and temperature generated with both sets of equations for 00Z Feb. 5 and 00Z Feb. 7 are shown in Figs. 8–11. The purpose is to show that both sets of equations generate similar initial-guess fields of height and temperature, especially over the back half of the hemisphere — essentially a no-data area in this study. Any differences that do occur are usually over "data" areas, and it is felt that the past- and present-data equations produce the more meaningful analysis.

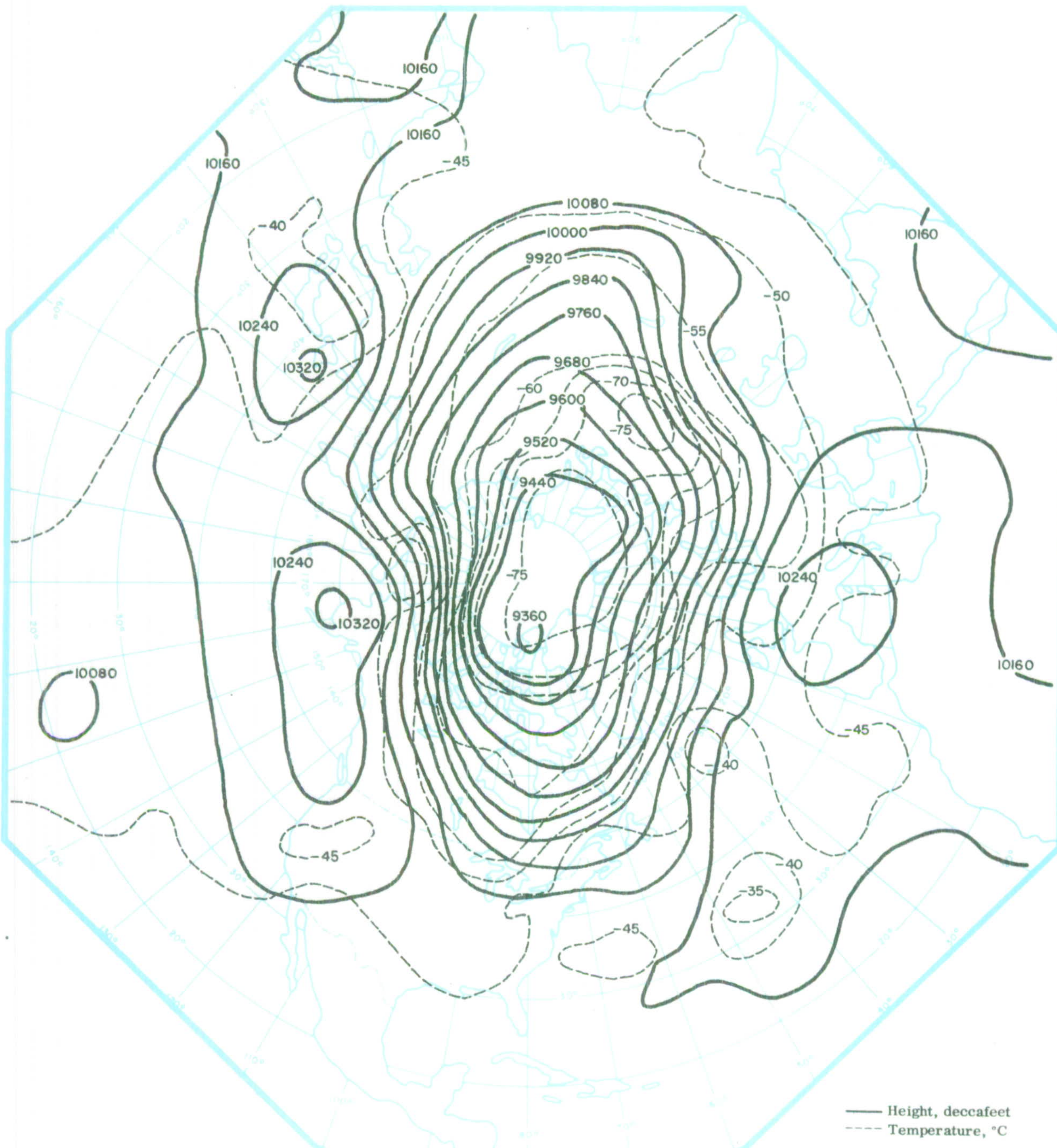

Fig. 6. Ten-mb height and temperature analysis: 00Z, 3 February initial guess — past and present data equations (Station 28952 excluded).

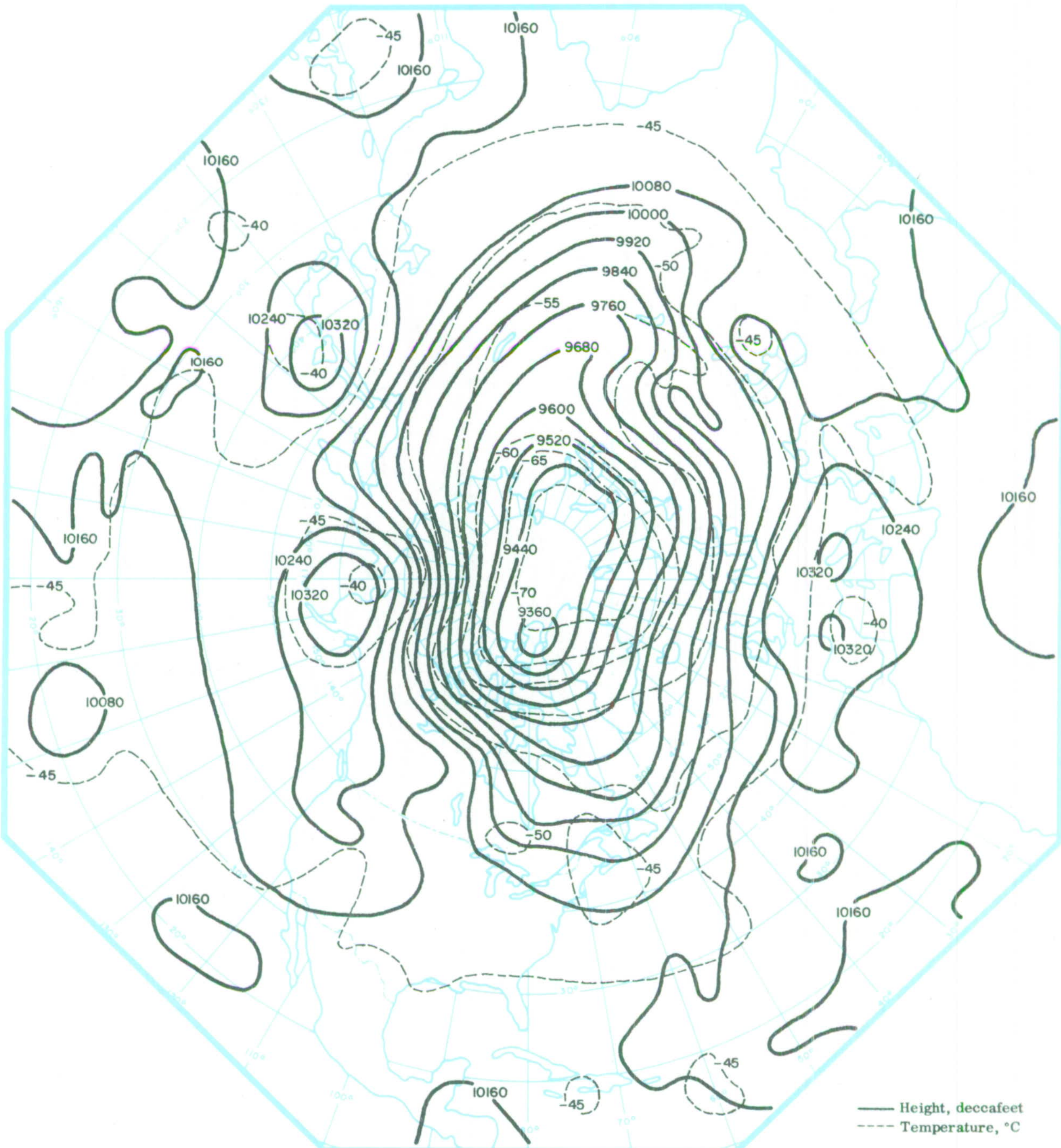

Fig. 7. Ten-mb height and temperature analysis: 00Z, 3 February initial guess — present data equations (Station 28952 excluded).

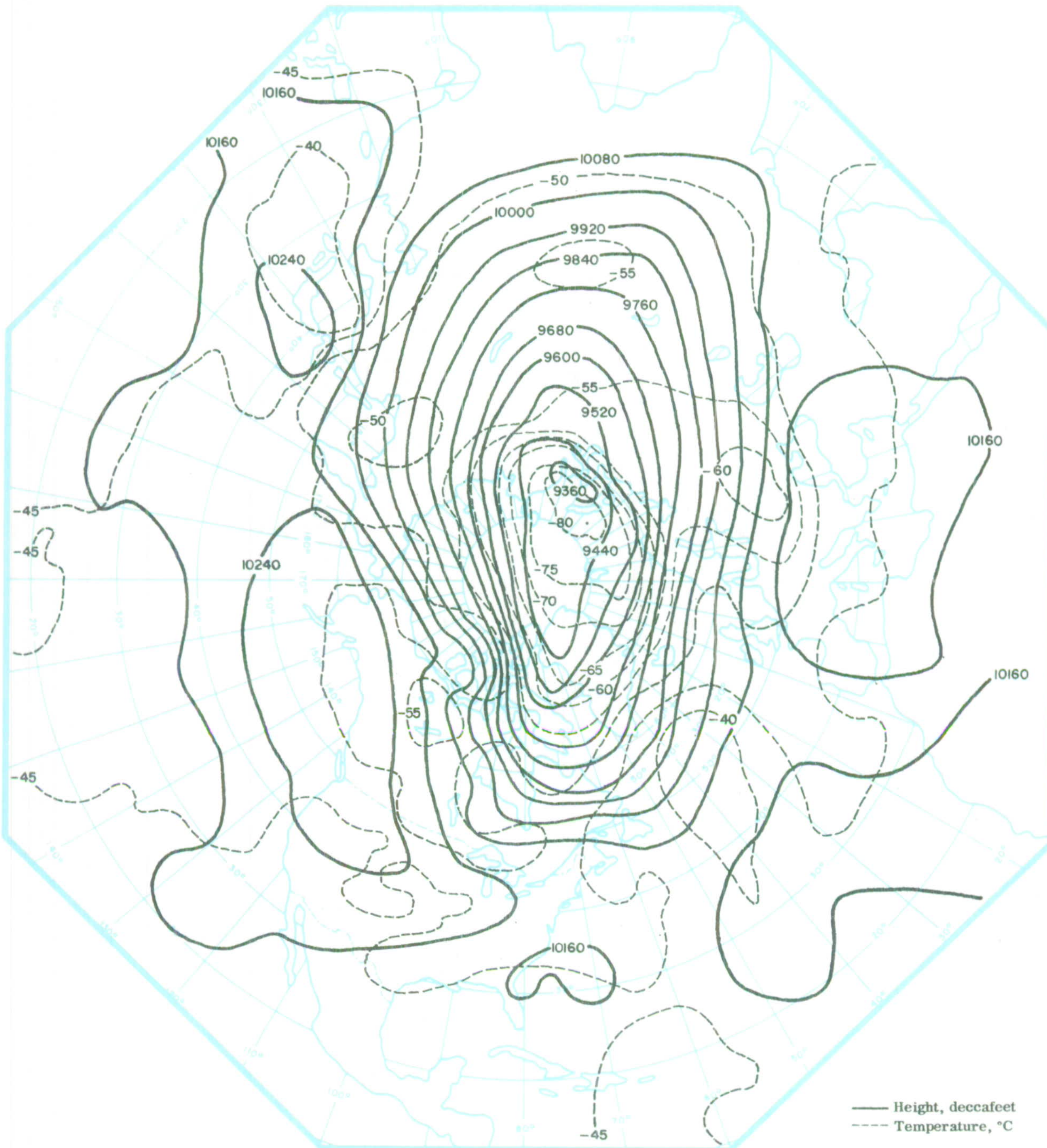

Fig. 8. Ten-mb height and temperature analysis: 00Z, 5 February initial guess — past and present data equations.

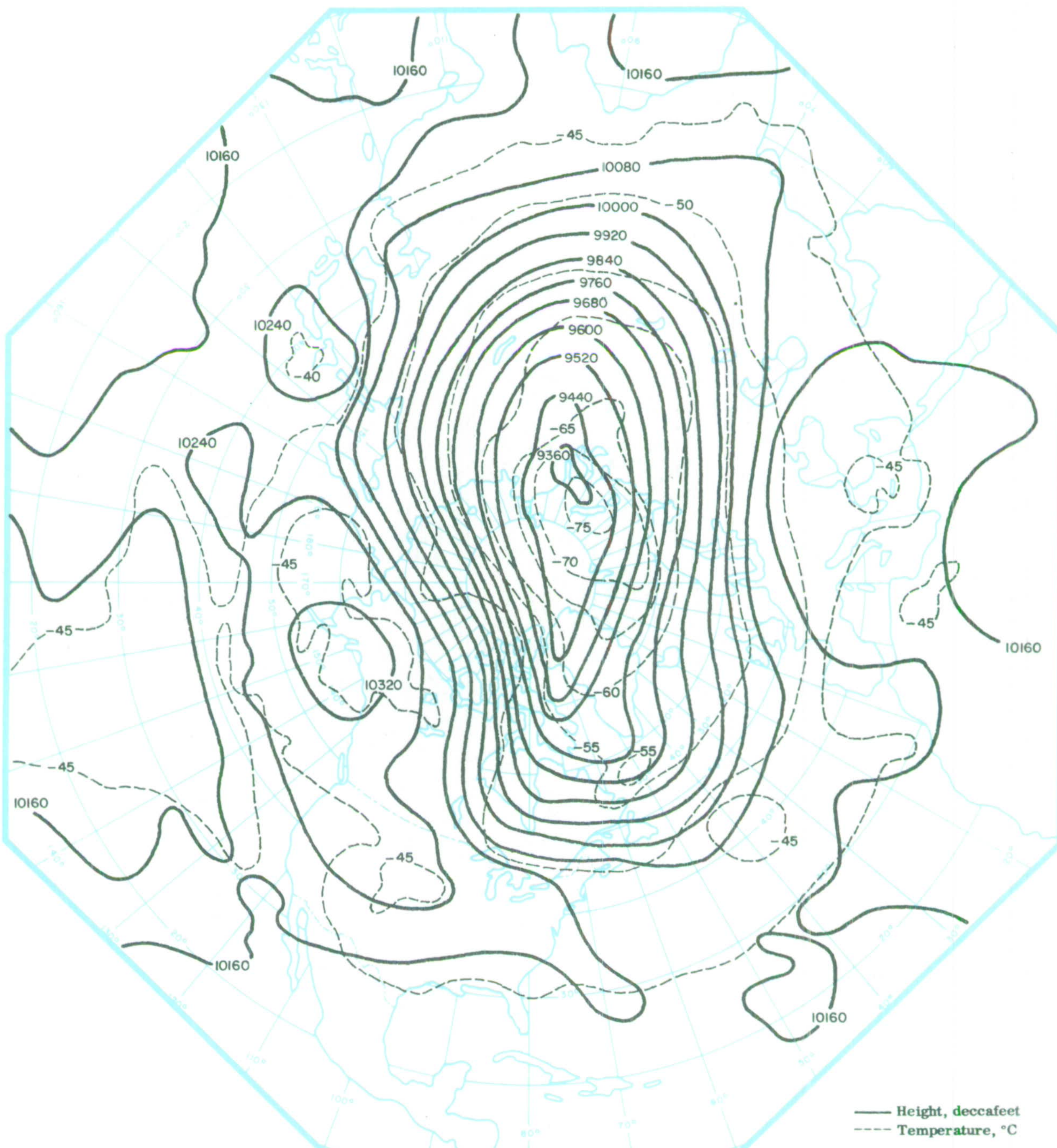

Fig. 9. Ten-mb height and temperature analysis: 00Z, 5 February initial guess — present data equations.

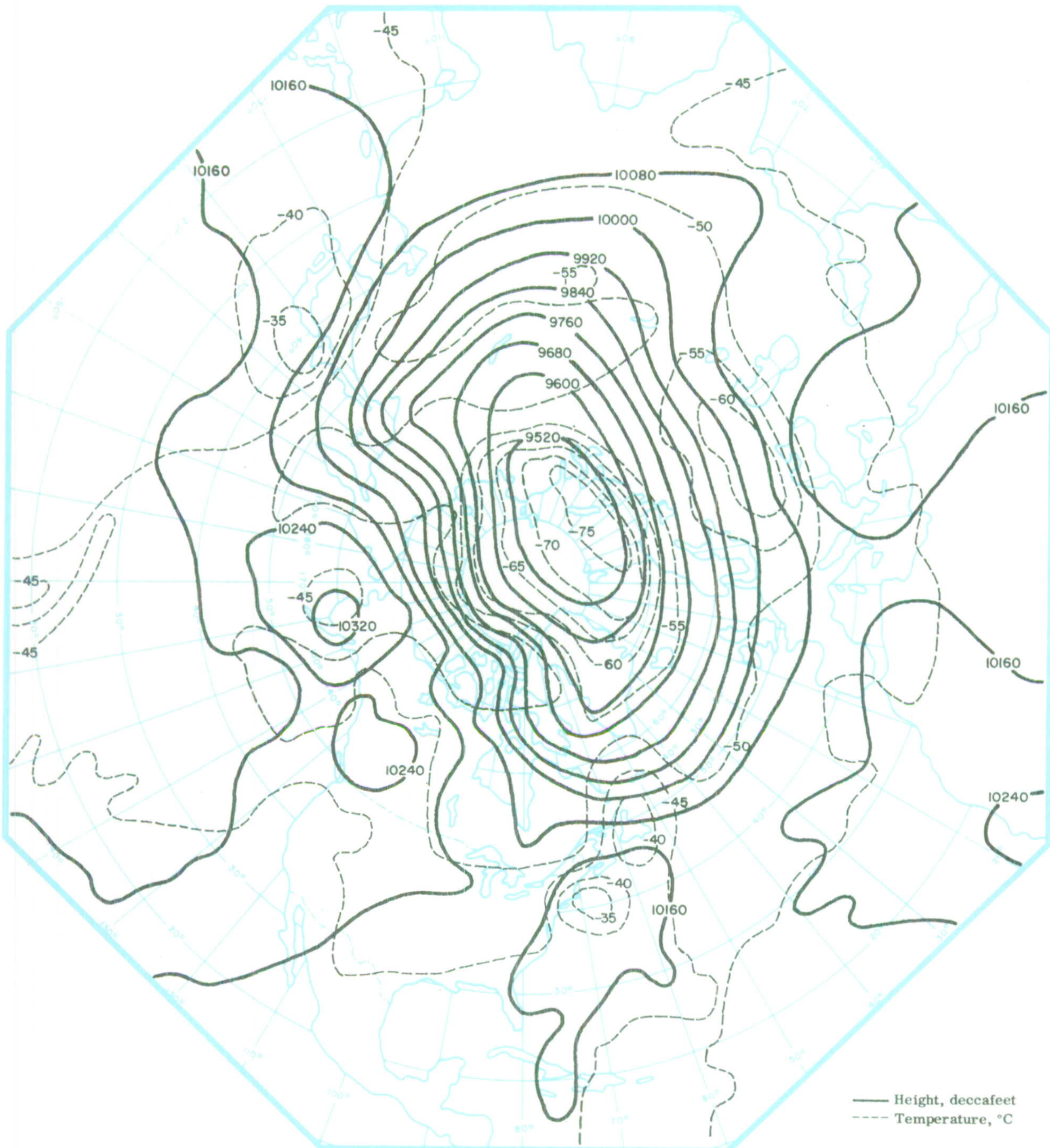

Fig. 10. Ten-mb height and temperature analysis: 00Z, 7 February initial guess — past and present data equations.

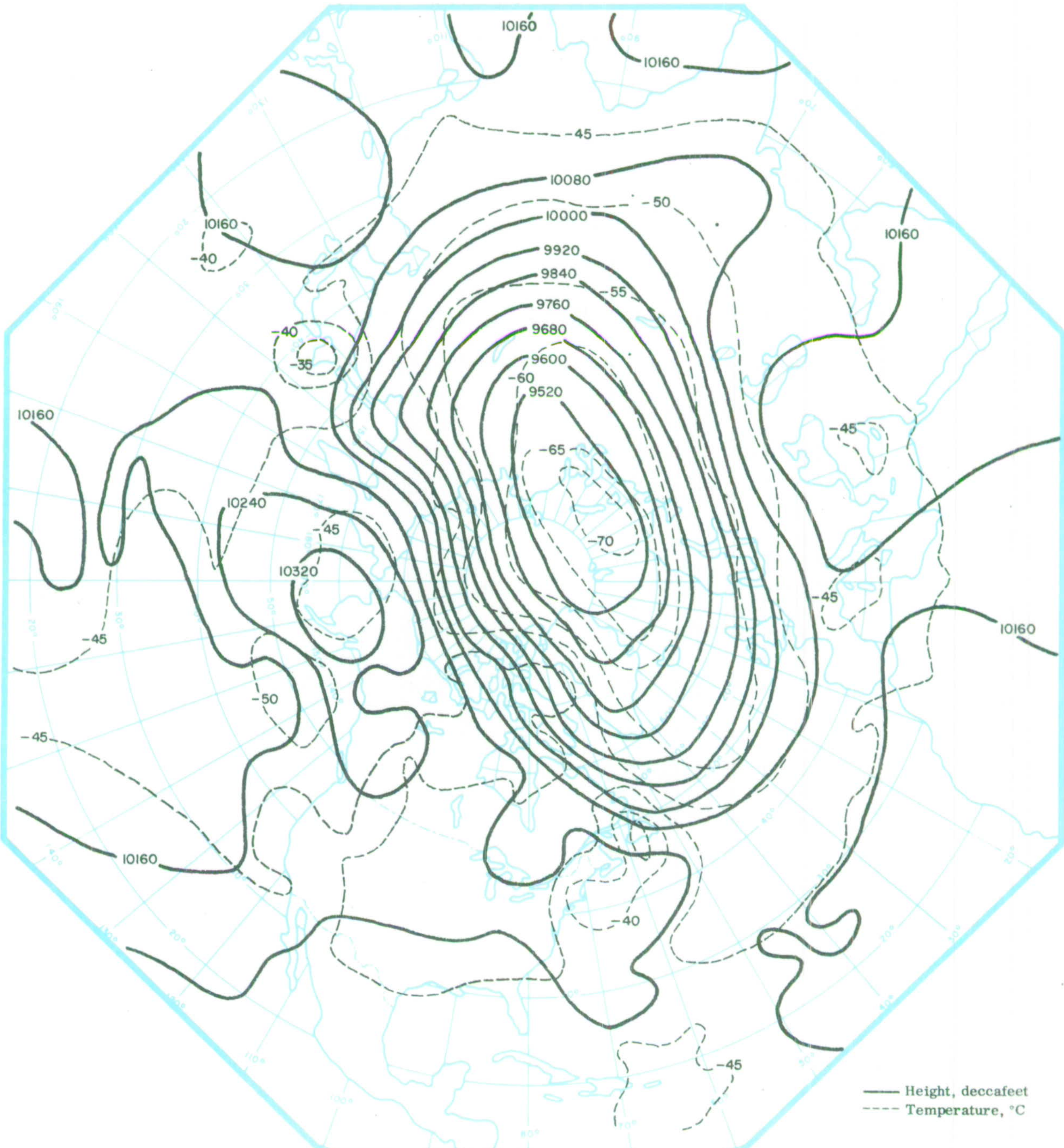

Fig. 11. Ten-mb height and temperature analysis: 00Z, 7 February initial guess — present data equations.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

The two sets of vertical extrapolation equations developed from a five-year data sample showed stability when tested on an independent data sample. The past- and present-data equations produced lower 10-mb height rms errors than did the present-data equations. The temperature equation rms errors were about the same. The past- and present-data equations should be used in the analysis technique over areas where previous (t_{-24}) data are available.

Results of experiments indicated that it is better to perform the height analysis first and to use $H_0(30-10)$ as a specifier of 10-mb temperatures.

The results of a Student "t" test comparing TRC equations with USWB equations for specifying 10-mb heights and temperatures clearly indicates that the inclusion of additional parameters in the TRC equations leads to significantly smaller specification errors.

The application of the TRC equations in the 10-mb analysis technique showed that both sets of equations (present-data only, and past- and present-data) produce similar initial-guess fields of 10-mb heights and temperatures. Any differences that do occur are usually over data areas, and it is felt that the past- and present-data equations produce the more meaningful analysis in these regions.

It is suggested that the 100–50 mb and 50–30 mb vertical extrapolation equations be rederived to make them compatible with the regime and band stratification used for the 10-mb equations.

APPENDIX I

TRC VERTICAL EXTRAPOLATION EQUATIONS FOR SPECIFYING 10-mb HEIGHTS AND TEMPERATURES

APPENDIX I

TRC VERTICAL EXTRAPOLATION EQUATIONS FOR 10-mb HEIGHTS AND TEMPERATURES*

1. Past and Present Data—December, January, February

Band **Predictand**

2A

$$Z_0(10) = 2269.2 + 0.6812[Z_{-24}(10)] - 1.5402[Z_{-24}(30)] + 0.8009[Z_{-24}(50)] + 7.4966[T_0(30)] + 1.0239[Z_0(30)]$$

$$T_0(10) = -384.85 + 0.1325[Z_0(10)] - 0.1325[Z_0(30)] - 0.6374[T_0(30)] + 0.1907[T_{-24}(10)]$$

4A

$$Z_0(10) = 256.22 + 0.9686[Z_{-24}(10)] - 1.1189[Z_{-24}(30)] + 1.2565[Z_0(30)]$$

$$T_0(10) = -344.98 + 0.1186[Z_0(10)] - 0.1186[Z_0(30)] - 0.5611[T_0(30)] + 0.2480[T_{-24}(10)]$$

5

$$Z_0(10) = 991.17 + 0.7681[Z_{-24}(10)] - 1.4040[Z_{-24}(30)] + 0.5858[Z_{-24}(50)] + 1.0989[Z_0(30)] + 3.734[T_0(30)]$$

$$T_0(10) = -240.82 + 0.0817[Z_0(10)] - 0.0817[Z_0(30)] + 0.3917[T_{-24}(10)] - 0.3721[T_{-24}(30)]$$

6

$$Z_0(10) = 986.02 + 0.7316[Z_{-24}(10)] - 0.9590[Z_{-24}(30)] + 1.1997[Z_0(30)] + 2.5889[T_0(30)]$$

$$T_0(10) = -394.66 + 0.1364[Z_0(10)] - 0.1364[Z_0(30)] - 0.6301[T_0(30)] + 0.1377[T_{-24}(10)]$$

7

$$Z_0(10) = 594.68 + 1.0711[Z_0(30)] + 0.5697[Z_{-24}(10)] - 0.5697[Z_{-24}(30)] + 2.4147[T_0(30)]$$

$$T_0(10) = -255.68 + 0.0875[Z_0(10)] - 0.0875[Z_0(30)] + 0.2519[T_{-24}(10)] - 0.2865[T_{-24}(30)]$$

8

$$Z_0(10) = 888.25 + 0.7443[Z_{-24}(10)] - 0.9606[Z_{-24}(30)] + 1.1929[Z_0(30)] + 1.8779[T_0(30)]$$

$$T_0(10) = -276.36 + 0.0976[Z_0(10)] - 0.0976[Z_0(30)] + 0.3171[T_{-24}(10)] - 0.2938[T_{-24}(30)]$$

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*Heights are in decafeet; temperatures are in °C.

2. Present Data—December, January, February

Band	Predictand
1	$Z_0(10) = 3324.5 + 0.9529[Z_0(30)] + 12.188[T_0(30)]$
	$T_0(10) = -460.15 + 0.1602[Z_0(10)] - 0.1602[Z_0(30)] - 0.3353[T_0(50)] - 0.3353[T_0(30)]$
2A	$Z_0(10) = 2575.2 + 1.0446[Z_0(30)] + 11.243[T_0(30)]$
	$T_0(10) = -467.15 + 0.1603[Z_0(10)] - 0.1603[Z_0(30)] - 0.7900[T_0(30)]$
4A	$Z_0(10) = 2440.1 + 1.0449[Z_0(30)] + 8.4884[T_0(30)]$
	$T_0(10) = -0452.96 + 0.1552[Z_0(10)] - 0.1552[Z_0(30)] - 0.7509[T_0(30)]$
5	$Z_0(10) = 1483.5 + 1.1567[Z_0(30)] + 6.5451[T_0(30)]$
	$T_0(10) = -366.31 + 0.1232[Z_0(10)] - 0.1232[Z_0(30)] - 0.2642[T_0(50)] - 0.2642[T_0(30)]$
6	$Z_0(10) = 2234.2 + 1.0729[Z_0(30)] + 8.4358[T_0(30)]$
	$T_0(10) = -458.32 + 0.1578[Z_0(10)] - 0.1578[Z_0(30)] - 0.7641[T_0(30)]$
7	$Z_0(10) = 1232.8 + 1.1778[Z_0(30)] + 4.6769[T_0(30)]$
	$T_0(10) = -335.19 + 0.1161[Z_0(10)] - 0.1161[Z_0(30)] - 0.3062[T_0(30)]$
8	$Z_0(10) = 381.02 + 1.2860[Z_0(30)] + 4.6352[T_0(30)]$
	$T_0(10) = -381.39 + 0.1340[Z_0(10)] - 0.1340[Z_0(30)] - 0.3904[T_0(30)]$

3. Past and Present Data—March

Band	Predictand
1	$Z_0(10) = 2367.8 + 8.2878[T_0(30)] + 0.9727[Z_0(30)] + 0.6938[Z_{-24}(10)] - 1.6155[Z_{-24}(30)] + 0.9217[Z_{-24}(50)]$
	$T_0(10) = -415.83 + 0.1814[Z_0(10)] - 0.1951[Z_0(30)] - 0.6403[T_0(30)] - 0.1296[T_{-24}(50)] - 0.1296[T_{-24}(30)]$
2	$Z_0(10) = 1767.9 + 1.9691[Z_0(30)] - 1.0042[Z_0(50)] + 0.6056[Z_{-24}(10)] - 1.8447[Z_{-24}(30)] + 1.2391[Z_{-24}(50)] + 6.0913[T_0(30)]$
	$T_0(10) = -528.01 + 0.1818[Z_0(10)] - 0.1818[Z_0(30)] - 0.8316[T_0(30)] - 0.0827[T_{-24}(50)] - 0.0827[T_{-24}(30)]$

Band | Predictand

3

$$Z_0(10) = 1700.4 + 0.4571[Z_{-24}(10)] - 0.6834[Z_{-24}(30)] + 1.2179[Z_0(30)] + 69891[T_0(30)]$$

$$T_0(10) = -426.10 + 0.1473[Z_0(10)] - 0.1473[Z_0(30)] - 0.4778[T_0(30)] - 0.1001[T_{-24}(50)] - 0.1001[T_{-24}(30)] + 0.0875[T_{-24}(10)]$$

4

$$Z_0(10) = 1473.2 + 0.6788[Z_{-24}(10)] - 0.8761[Z_{-24}(30)] + 1.1321[Z_0(30)] + 3.9846[T_0(30)]$$

$$T_0(10) = -209.32 + 0.4383[T_{-24}(10)] - 0.2854[T_{-24}(30)] + 0.0711[Z_0(10)] - 0.0711[Z_0(30)]$$

5

$$Z_0(10) = 1480.8 + 0.6684[Z_{-24}(10)] - 1.3374[Z_{-24}(30)] + 0.5690[Z_{-24}(50)] + 1.1149[Z_0(30)] + 5.5190[T_0(30)]$$

$$T_0(10) = -265.43 - 0.3621[T_{-24}(10)] - 0.1428T_{-24}(30)] + 0.0884[Z_0(10)] - 0.0884[Z_0(30)] - 0.1820[T_0(50)] - 0.1820[T_0(30)]$$

6

$$Z_0(10) = 2234.9 + 0.7197[Z_{-24}(10)] - 1.5388[Z_{-24}(30)] + 0.6898[Z_{-24}(50)] + 1.0617[Z_0(30)] + 5.7838[T_0(30)]$$

$$T_0(10) = -281.42 + 0.2311[T_{-24}(10)] - 0.2838[T_{-24}(30)] + 0.1291[Z_0(10)] - 0.1423[Z_0(30)] - 0.5593[T_0(30)]$$

7

$$Z_0(10) = 1202.9 = 1.0526[Z_0(30)] + 0.5306[Z_{-24}(10)] - 0.8566[Z_{-24}(30)] + 0.3260[Z_{-24}(50)] + 2.8832[T_0(30)]$$

$$T_0(10) = -305.58 + 0.1076[Z_0(10)] - 0.1076[Z_0(30)] - 0.1372[T_0(30)] + 0.2059[T_0(50)] + 0.1661[T_{-24}(10)] - 0.3817[T_{-24}(30)]$$

8

$$Z_0(10) = 1509.4 + 0.7187[Z_{-24}(10)] - 1.3290[Z_{-24}(30)] + 0.4392[Z_{-24}(50)] + 4.8445[T_0(30)] + 1.1567[Z_0(30)]$$

$$T_0(10) = -250.25 + 0.0894[Z_0(10)] - 0.0894[Z_0(30)] + 0.2876[T_{-24}(10)] - 0.1643[T_{-24}(30)]$$

4. Present Data—March

Band	Predictand
1	$Z_0(10) = 4622.8 + 13.951[T_0(30)] + 0.7983[Z_0(30)]$
	$T_0(10) = -520.46 + 0.1801[Z_0(10)] - 0.1801[Z_0(30)] - 0.9319[T_0(30)]$
2	$Z_0(10) = 3321.1 + 0.9582[Z_0(30)] + 12.674[T_0(30)]$
	$T_0(10) = -482.91 + 0.1669[Z_0(10)] - 0.1669[Z_0(30)] - 0.2050[T_0(50)] - 0.6015[T_0(30)]$
3	$Z_0(10) = 3212.3 + 0.7736[Z_0(30)] + 0.2348[Z_0(50)] + 13.091[T_0(30)]$
	$T_0(10) = -469.01 + 0.1637[Z_0(10)] - 0.1637[Z_0(30)] - 0.6835[T_0(30)]$
4	$Z_0(10) = 2879.3 + 0.9998[Z_0(30)] + 9.9652[T_0(30)]$
	$T_0(10) = -400.77 + 0.1378[Z_0(10)] - 0.1378[Z_0(30)] - 0.5517[T_0(30)]$
5	$Z_0(10) = 1323.9 + 1.1823[Z_0(30)] + 7.0132[T_0(30)]$
	$T_0(10) = -361.56 + 0.1239[Z_0(10)] - 0.1239[Z_0(30)] - 0.4513[T_0(30)]$
6	$Z_0(10) = 3920.2 - 0.0503[Z_0(30)] + 1.0851[Z_0(50)] + 12.611[T_0(30)]$
	$T_0(10) = -483.82 + 0.1640[Z_0(10)] - 0.1640[Z_0(30)] - 0.9767[T_0(30)]$
7	$Z_0(10) = 2320.2 + 1.0330[Z_0(30)] + 3.8186[T_0(30)]$
	$T_0(10) = -324.69 + 0.1121[Z_0(10)] - 0.1121[Z_0(30)] - 0.3092[T_0(30)]$
8	$Z_0(10) = 2576.1 + 8.5124[T_0(30)] + 1.0339[Z_0(30)]$
	$T_0(10) = -328.77 + 0.1163[Z_0(10)] - 0.1163[Z_0(30)] - 0.2059[T_0(30)]$

5. Past and Present Data—April

Band	Predictand
1	$Z_0(10) = 2058.8 + 0.693[Z_{-24}(10)] - 0.7687[Z_{-24}(30)] + 4.7974[T_0(30)] + 0.9367[Z_0(30)]$
	$T_0(10) = -351.69 + 0.3330[T_{-24}(10)] + 0.1211[Z_0(10)] - 0.1211[Z_0(30)] - 0.6848[T_0(30)]$
2	$Z_0(10) = 1831.4 + 0.7140[Z_{-24}(10)] - 1.4318[Z_{-24}(30)] + 0.6982[Z_{-24}(50)] + 1.0103[Z_0(30)] + 6.3295[T_0(30)]$
	$T_0(10) = -372.14 + 0.1283[Z_0(10)] - 0.1283[Z_0(30)] - 0.6777[T_0(30)] + 0.2595[T_{-24}(10)]$

Band	Predictand
3	$Z_0(10) = 541.00 + 1.1199[Z_0(30)] + 0.4694[Z_{-24}(10)] - 0.4694[Z_{-24}(30)] + 4.5241[T_0(30)]$
	$T_0(10) = -357.76 + 0.1236[Z_0(10)] - 0.1236[Z_0(30)] - 0.3532[T_0(30)] - 0.2288[T_{-24}(10)] - 0.2338[T_{-24}(30)]$
4	$Z_0(10) = 1144.6 + 1.4053[Z_0(30)] - 0.3435[Z_0(50)] + 0.5886[Z_{-24}(10)] - 1.3261[Z_{-24}(30)] + 0.7375[Z_{-24}(50)] + 4.491[T_0(30)]$
	$T_0(10) = -369.85 + 0.1280[Z_0(10)] - 0.1280[Z_0(30)] - 0.5628[T_0(30)] + 0.1650[T_{-24}(10)]$
5	$Z_0(10) = 1701.8 + 0.6983[Z_{-24}(10)] - 1.6272[Z_{-24}(30)] + 0.6958[Z_{-24}(50)] + 1.2374[Z_0(30)] + 5.1802[T_0(30)]$
	$T_0(10) = -323.54 + 0.1105[Z_0(10)] - 0.1105[Z_0(30)] - 0.2379[T_0(30)] + 0.2836[T_{-24}(10)] - 0.3264[T_{-24}(30)]$
6	$Z_0(10) = 2025.1 + 0.6559[Z_{-24}(10)] - 1.5980[Z_{-24}(30)] + 0.9327[Z_{-24}(50)] + 1.0255[Z_0(30)] + 6.3704[T_0(30)]$
	$T_0(10) = -354.28 + 0.1189[Z_0(10)] - 0.1189[Z_0(30)] - 0.4470[T_0(30)] + 0.28391[T_{-24}(10)] - 0.33246[T_{-24}(30)]$
7	$Z_0(10) = 688.13 + 1.2487[Z_0(30)] + 0.5694[Z_{-24}(10)] - 0.7564[Z_{-24}(30)] + 2.60[T_0(30)]$
	$T_0(10) = -295.29 + 0.1008[Z_0(10)] - 0.1008[Z_0(30)] + 0.2144[T_{-24}(10)] - 0.2653[T_{-24}(30)] - 0.1554[T_0(30)]$
8	$Z_0(10) = 1745.4 + 1.2610[Z_0(30)] + 0.5660[Z_{-24}(10)] - 0.8903[Z_{-24}(30)] + 3.9533[T_0(30)]$
	$T_0(10) = -245.82 + 0.0827[Z_0(10)] - 0.0827[Z_0(30)] + 0.2257[T_{-24}(10)] - 0.3159[T_{-24}(30)]$

6. Present Data—April

Band	Predictand
1	$Z_0(10) = 3384.2 + 0.9401[Z_0(30)] + 10.932[T_0(30)]$
	$T_0(10) = -492.31 + 0.1692[Z_0(10)] - 0.1692[Z_0(30)] - 0.8959[T_0(30)]$

Band	Predictand

2 $Z_0(10) = 2601.5 + 1.0359[Z_0(30)] + 10.334[T_0(30)]$

$T_0(10) = -470.26 + 0.1622[Z_0(10)] - 0.1622[Z_0(30)] - 0.7889[T_0(30)]$

3 $Z_0(10) = 995.52 + 1.2304[Z_0(30)] + 8.6766[T_0(30)]$

$T_0(10) = -429.40 + 0.1488[Z_0(10)] - 0.1488[Z_0(30)] - 0.6119[T_0(30)]$

4 $Z_0(10) = 1997.7 + 1.0933[Z_0(30)] + 7.1946[T_0(30)]$

$T_0(10) = -435.78 + 0.1500[Z_0(10)] - 0.1500[Z_0(30)] - 0.6831[T_0(30)]$

5 $Z_0(10) = 2676.5 - 0.0280[Z_0(30)] + 1.2374[Z_0(50)] + 11.654[T_0(30)]$

$T_0(10) = -229.78 + 0.1452[Z_0(10)] - 0.1687[Z_0(30)] - 0.4859[T_0(30)]$

6 $Z_0(10) = 3449.6 - 0.0784[Z_0(30)] + 1.1833[Z_0(50)] + 12.060[T_0(30)]$

$T_0(10) = -445.52 + 0.1524[Z_0(10)] - 0.1524[Z_0(30)] - 0.7746[T_0(30)]$

7 $Z_0(10) = 1264.5 + 1.1806[Z_0(30)] + 5.2868[T_0(30)]$

$T_0(10) = -310.64 + 0.1075[Z_0(10)] - 0.1075[Z_0(30)] - 0.2541[T_0(30)]$

8 $Z_0(10) = 1702.3 + 1.1310[Z_0(30)] + 6.2547[T_0(30)]$

$T_0(10) = -286.06 + 0.0974[Z_0(10)] - 0.0974[Z_0(30)] - 0.2439[T_0(30)]$

7. Past and Present Data—May

Band	Predictand

1 $Z_0(10) = 3235.3 + 0.69747[Z_0(30)] + 10.762[T_0(30)] + 0.48976[Z_{-24}(10)]$

$- 1.70346[Z_{-24}(30)] + 1.2137[Z_{-24}(50)] + 0.33033[Z_0(50)]$

$T_0(10) = -405.07 + 0.14057[Z_0(10)] - 0.14057[Z_0(30)] - 0.69257[T_0(30)]$

$+ 0.19037[T_{-24}(10)]$

2 $Z_0(10) = 99.335 + 1.3366[Z_0(30)] + 0.77099[Z_{-24}(10)] - 1.050[Z_{-24}(30)]$

$T_0(10) = -466.56 + 0.1601[Z_0(10)] - 0.1601[Z_0(30)] - 0.19512[T_0(50)]$

$- 0.64832[T_0(30)]$

3 $Z_0(10) = 1928.8 + 0.99613[Z_0(30)] + 7.8051[T_0(30)] + 0.36914[Z_{-24}(10)]$

$- 0.36914[Z_{-24}(30)]$

$T_0(10) = -569.30 + 0.20186[Z_0(10)] - 0.20186[Z_0(30)] - 1.26053[T_0(30)]$

$+ 0.35577[T_0(50)]$

Band	Predictand
4	$Z_0(10) = 1500.3 + 1.7466[Z_0(30)] - 0.7354[Z_0(50)] + 0.66285[Z_{-24}(10)]$ $- 1.79795[Z_{-24}(30)] + 1.2351[Z_{-24}(50)] + 4.677[T_0(30)]$
	$T_0(10) = - 452.92 + 0.15664[Z_0(10)] - 0.15664[Z_0(30)] - 0.40592[T_0(30)]$ $+ 0.05142[T_{-24}(50)] - 0.49028[T_{-24}(30)] + 0.13601[T_{-24}(10)]$
5	$Z_0(10) = 1423.8 + 1.0877[Z_0(30)] + 5.7789[T_0(30)] + 0.58129[Z_{-24}(10)]$ $- 1.33602[Z_{-24}(30)] + 0.75473[Z_{-24}(50)]$
	$T_0(10) = - 379.84 + 0.1301[Z_0(10)] - 0.1301[Z_0(30)] - 0.35576[T_0(30)]$ $- 0.30444[T_{-24}(30)] + 0.16735[T_{-24}(10)]$
6	$Z_0(10) = 1507.6 + 0.98025[Z_0(30)] + 3.8082[T_0(30)] + 0.51477[Z_{-24}(10)]$ $- 0.50956[Z_{-24}(30)] - 0.00521[Z_{-24}(50)]$
	$T_0(10) = - 402.38 + 0.14039[Z_0(10)] - 0.14039[Z_0(30)] + 0.28762[T_0(50)]$ $- 0.92248[T_0(30)] + 0.14498[T_{-24}(10)]$
7	$Z_0(10) = 623.31 + 1.1379[Z_0(30)] + 0.3604[Z_{-24}(10)] - 0.3604[Z_{-24}(30)]$ $+ 3.2636[T_0(30)]$
	$T_0(10) = - 109.01 + 0.090998[Z_0(10)] - 0.109366[Z_0(30)] + 0.12688[T_{-24}(10)]$
8	$Z_0(10) = 1212.0 + 1.0661[Z_0(30)] + 4.3270[T_0(30)] + 0.64354[Z_{-24}(10)]$ $- 1.25061[Z_{-24}(30)] + 0.60707[Z_{-24}(50)]$
	$T_0(10) = - 216.54 + 0.075573[Z_0(10)] - 0.075573[Z_0(30)] - 0.36384[T_{-24}(30)]$ $+ 0.17973[T_{-24}(10)] + 0.3145[T_0(30)]$

8. Present Data—May

Band	Predictand
1	$Z_0(10) = 4872.3 - 1.0760[Z_0(30)] + 2.1750[Z_0(50)] + 17.480[T_0(30)]$
	$T_0(10) = - 465.34 + 0.16091[Z_0(10)] - 0.16091[Z_0(30)] - 0.76577[T_0(30)]$
2	$Z_0(10) = 2654.4 + 0.74404[Z_0(30)] + 0.31756[Z_0(50)] + 7.8293[T_0(30)]$
	$T_0(10) = - 459.59 + 0.15738[Z_0(10)] - 0.15738[Z_0(30)] - 0.82979[T_0(30)]$
3	$Z_0(10) = 2980.5 + 0.32621[Z_0(30)] + 0.77929[Z_0(50)] + 11.342[T_0(30)]$
	$T_0(10) = - 512.95 + 0.17874[Z_0(10)] - 0.17874[Z_0(30)] - 0.8764[T_0(30)]$

Band	Predictand
4	$Z_0(10) = 2290.6 + 0.5352[Z_0(30)] + 0.6197[Z_0(50)] + 8.8075[T_0(30)]$
	$T_0(10) = -473.21 + 0.16338[Z_0(10)] - 0.16338[Z_0(30)] - 0.81368[T_0(30)]$
5	$Z_0(10) = 2241.5 + 0.1900[Z_0(30)] + 1.0436[Z_0(50)] + 10.873[T_0(30)]$
	$T_0(10) = -403.06 + 0.13924[Z_0(10)] - 0.13924[Z_0(30)] - 0.5544[T_0(30)]$
6	$Z_0(10) = 3025.5 + 0.2274[Z_0(30)] + 0.8807[Z_0(50)] + 10.415[T_0(30)]$
	$T_0(10) = -421.83 + 0.14629[Z_0(10)] - 0.14629[Z_0(30)] - 0.864035[T_0(30)] + 0.243465[T_0(50)]$
7	$Z_0(10) = 1137.5 + 1.72436[Z_0(30)] - 0.62196[Z_0(50)] + 3.8658[T_0(30)]$
	$T_0(10) = -119.92 + 0.10134[Z_0(10)] - 0.12213[Z_0(30)]$
8	$Z_0(10) = 1814.3 + 1.115[Z_0(30)] + 5.9867[T_0(30)]$
	$T_0(10) = -217.53 + 0.097643[Z_0(10)] - 0.104845[Z_0(30)]$

9. Past and Present Data—June, July, 1/2 August (1—15)

Band	Predictand
1	$Z_0(10) = 1988.9 + 1.0036[Z_0(30)] + 0.6009[Z_{-24}(10)] - 1.24385[Z_{-24}(30)] + 0.64295[Z_{-24}(50)] + 7.125[T_0(30)]$
	$T_0(10) = -401.68 + 0.14051[Z_0(10)] - 0.14051[Z_0(30)] - 0.39504[T_0(30)] + 0.149715[T_{-24}(10)] - 0.196605[T_{-24}(30)]$
2	$Z_0(10) = 1850.6 + 0.99791[Z_0(30)] + 0.59124[Z_{-24}(10)] - 1.10224[Z_{-24}(30)] + 0.511[Z_{-24}(50)] + 5.7607[T_0(30)]$
	$T_0(10) = -414.47 + 0.14353[Z_0(10)] - 0.14353[Z_0(30)] - 0.69459[T_0(30)] + 0.12523[T_{-24}(10)]$
3	$Z_0(10) = 1421.8 + 1.95869[Z_0(30)] - 0.91059[Z_0(50)] + 3.7031[T_0(30)] + 0.37711[Z_{-24}(10)] - 1.31552[Z_{-24}(30)] + 0.93841[Z_{-24}(50)]$
	$T_0(10) = -437.09 + 0.15001[Z_0(10)] - 0.15001[Z_0(30)] - 0.177795[T_0(50)] - 0.554115[T_0(30)]$

Band	Predictand
4	$Z_0(10) = 1682.9 + 1.2435[Z_0(30)] + 4.6478[T_0(30)] + 0.31750[Z_{-24}(10)] - 0.53576[Z_{-24}(30)]$
	$T_0(10) = -264.31 + 0.13604[Z_0(10)] - 1.54064[Z_0(30)] - 0.37164[T_0(30)] + 0.17881[T_0(50)]$
5	$Z_0(10) = 1064.0 + 1.3019[Z_0(30)] + 3.3702[T_0(30)] + 0.43259[Z_{-24}(10)] - 0.67436[Z_{-24}(30)]$
	$T_0(10) = 201.81 + 0.10631[Z_0(10)] - 0.117716[Z_0(30)] + 0.079653[T_{-24}(10)]$
6	$Z_0(10) = 1482.4 + 1.2567[Z_0(30)] + 5.609[T_0(30)] + 0.2611[Z_{-24}(10)] - 0.44447[Z_{-24}(30)]$
	$T_0(10) = -300.69 + 0.12683[Z_0(10)] - 0.133596[Z_0(30)] - 0.19561[T_0(30)]$
7	$Z_0(10) = 953.79 + 1.0743[Z_0(30)] + 0.42748[Z_{-24}(10)] - 0.42748[Z_{-24}(30)] + 3.2084[T_0(30)]$
	$T_0(10) = -168.86 + 0.087103[Z_0(10)] - 0.0969068[Z_0(30)] + 0.089489[T_{-24}(10)]$
8	$Z_0(10) = 881.28 + 1.60249[Z_0(30)] - 0.54379[Z_0(50)] + 3.1667[T_0(30)] + 0.2664[Z_{-24}(10)] - 0.2664[Z_{-24}(30)]$
	$T_0(10) = -287.11 + 0.10242[Z_0(10)] - 0.10242[Z_0(30)] + 0.062582[T_{-24}(10)] - 0.068159[T_0(30)]$

10. Present Data—June, July, 1/2 August (1—15)

Band	Predictand
1	$Z_0(10) = 3392.9 + 0.34927[Z_0(30)] + 0.69323[Z_0(50)] + 11.241[T_0(30)]$
	$T_0(10) = -395.30 + 0.1388[Z_0(10)] - 0.1388[Z_0(30)] - 0.42019[T_0(30)]$
2	$Z_0(10) = 2472.8 + 1.036[Z_0(30)] + 6.781[T_0(30)]$
	$T_0(10) = -415.58 + 0.14424[Z_0(10)] - 0.14424[Z_0(30)] - 0.28672[T_0(50)] - 0.28672[T_0(30)]$
3	$Z_0(10) = 2444.9 + 1.0397[Z_0(30)] + 6.892[T_0(30)]$
	$T_0(10) = -418.48 + 0.14456[Z_0(10)] - 0.14456[Z_0(30)] - 0.306075[T_0(50)] - 0.306075[T_0(30)]$

Band	Predictand
4	$Z_0(10) = 1628.7 + 1.1373[Z_0(30)] + 6.0409[T_0(30)]$
	$T_0(10) = -230.62 + 0.13492[Z_0(10)] - 0.153176[Z_0(30)] - 0.23118[T_0(30)]$
5	$Z_0(10) = 1054.3 + 0.64155[Z_0(30)] - 0.51885[Z_0(50)] + 3.4235[T_0(30)]$
	$T_0(10) = -131.79 + 0.10627[Z_0(10)] - 0.125715[Z_0(30)] + 0.08661[T_0(50)] + 0.08661[T_0(30)]$
6	$Z_0(10) = 1773.2 + 1.1207[Z_0(30)] + 6.3807[T_0(30)]$
	$T_0(10) = -297.73 + 0.13325[Z_0(10)] - 0.142416[Z_0(30)] - 0.20885[T_0(30)]$
7	$Z_0(10) = 1705.9 + 1.1197[Z_0(30)] + 4.8823[T_0(30)]$
	$T_0(10) = -220.82 + 0.091553[Z_0(10)] - 0.096875[Z_0(30)] - 0.043861[T_0(30)]$
8	$Z_0(10) = 1163.3 + 1.75279[Z_0(30)] - 0.66229[Z_0(50)] + 3.6123[T_0(30)]$
	$T_0(10) = -248.26 + 0.089354[Z_0(10)] - 0.089354[Z_0(30)] + 0.057875[T_0(50)] + 0.057875[T_0(30)]$

11. Past and Present Data—1/2 August (16—31), September

Band	Predictand
1	$Z_0(10) = 1226.8 + 1.0868[Z_0(30)] + 0.6898[Z_{-24}(10)] - 1.4961[Z_{-24}(30)] + 0.8063[Z_{-24}(50)] + 5.8009[T_0(30)]$
	$T_0(10) = -329.19 + 0.11479[Z_0(10)] - 0.11479[Z_0(30)] - 0.24559[T_0(30)] + 0.25259[T_{-24}(10)] - 0.103175[T_{-24}(50)] - 0.103175[T_{-24}(30)]$
2	$Z_0(10) = 944.98 + 0.720854[Z_{-24}(10)] - 0.8053[Z_{-24}(30)] + 4.6491[T_0(30)]$
	$T_0(10) = -339.09 + 0.11937[Z_0(10)] - 0.11937[Z_0(30)] - 0.445[T_0(30)] + 0.26909[T_{-24}(10)]$
3	$Z_0(10) = 621.8 + 1.0348[Z_0(30)] + 0.6739[Z_{-24}(10)] - 0.6739[Z_{-24}(30)] + 2.3992[T_0(30)]$
	$T_0(10) = -496.76 + 0.17324[Z_0(10)] - 0.17324[Z_0(30)] - 0.85131[T_0(30)] + 0.067205[T_{-24}(10)]$

Band	Predictand

4 $$Z_0(10) = 1284.4 + 1.1141[Z_0(30)] + 0.52705[Z_{-24}(10)] - 1.20957[Z_{-24}(30)] + 0.68252[Z_{-24}(50)] + 6.2393[T_0(30)]$$

$$T_0(10) = -340.10 + 0.11832[Z_0(10)] - 0.11832[Z_0(30)] - 0.27826[T_0(30)] + 0.24551[T_{-24}(10)] - 0.21413[T_{-24}(30)]$$

5 $$Z_0(10) = 400.34 + 1.71471[Z_0(30)] - 0.55351[Z_0(50)] + 0.53437[Z_{-24}(10)] - 1.4347[Z_{-24}(30)] + 0.90033[Z_{-24}(50)] + 3.674[T_0(30)]$$

$$T_0(10) = -312.50 + 0.10865[Z_0(10)] - 0.10865[Z_0(30)] - 0.149875[T_{-24}(50)] - 0.149875[T_{-24}(30)] + 0.12986[T_{-24}(10)]$$

6 $$Z_0(10) = 332.82 + 1.50185[Z_0(30)] - 0.27375[Z_0(50)] + 5.0755[T_0(30)] + 0.40565[Z_{-24}(10)] - 1.10682[Z_{-24}(30)] + 0.70117[Z_{-24}(50)]$$

$$T_0(10) = -368.72 + 0.13047[Z_0(10)] - 0.13047[Z_0(30)] - 0.40427[T_0(30)] + 0.13479[T_{-24}(10)]$$

7 $$Z_0(10) = 1209.2 + 1.0189[Z_0(30)] + 0.49349[Z_{-24}(10)] - 0.49349[Z_{-24}(30)] + 2.8387[T_0(30)]$$

$$T_0(10) = -167.10 + 0.099233[Z_0(10)] - 0.113495[Z_0(30)] + 0.171745[T_{-24}(10)] - 0.145835[T_{-24}(30)]$$

8 $$Z_0(10) = 692.38 + 1.318[Z_0(30)] + 0.52368[Z_{-24}(10)] - 0.77132[Z_{-24}(30)] + 2.1127[T_0(30)]$$

$$T_0(10) = -243.24 + 0.12364[Z_0(10)] - 0.135411[Z_0(30)] + 0.018701[T_{-24}(10)]$$

12. Present Data—1/2 August (16—31), September

Band	Predictand

1 $$Z_0(10) = 1600.1 + 0.49716[Z_0(30)] + 0.76594[Z_0(50)] + 9.0294[T_0(30)]$$

$$T_0(10) = -404.3 + 0.15571[Z_0(10)] - 0.1603824[Z_0(30)] - 0.51378[T_0(30)]$$

2 $$Z_0(10) = 1898.6 + 1.1216[Z_0(30)] + 9.4179[T_0(30)]$$

$$T_0(10) = -400.67 + 0.14076[Z_0(10)] - 0.14076[Z_0(30)] - 0.113085[T_0(50)] - 0.310415[T_0(30)]$$

Band Predictand

3 $Z_0(10) = 2243.1 + 0.60613[Z_0(30)] + 0.54927[Z_0(50)] + 9.6266[T_0(30)]$

$T_0(10) = - 476.32 + 0.16689[Z_0(10)] - 0.16689[Z_0(30)] - 0.6826[T_0(30)]$

4 $Z_0(10) = 1406.9 + 0.56964[Z_0(30)] + 0.71396[Z_0(50)] + 9.6371[T_0(30)]$

$T_0(10) = - 381.92 + 0.13402[Z_0(10)] - 0.13402[Z_0(30)] - 3.7419[T_0(30)]$

5 $Z_0(10) = 448.24 + 1.275[Z_0(30)] + 4.5126[T_0(30)]$

$T_0(10) = - 319.98 + 0.11068[Z_0(10)] - 0.11068[Z_0(30)] - 0.12261[T_0(50)] - 0.12261[T_0(30)]$

6 $Z_0(10) = - 476.61 + 1.3822[Z_0(30)] + 3.2255[T_0(30)]$

$T_0(10) = - 360.67 + 0.12777[Z_0(10)] - 0.12777[Z_0(30)] - 0.26067[T_0(30)]$

7 $Z_0(10) = 1776.7 + 1.1067[Z_0(30)] + 4.3956[T_0(30)]$

$T_0(10) = - 139.61 + 0.10479[Z_0(10)] - 0.124134[Z_0(30)]$

8 $Z_0(10) = 489.71 + 1.2587[Z_0(30)] + 2.7603[T_0(30)]$

$T_0(10) = - 194.51 + 0.11697[Z_0(10)] - 0.132994[Z_0(30)]$

13. Past and Present Data—October-November

Band Predictand

1 $Z_0(10) = 82.542 + 0.97006[Z_{-24}(10)] - 1.2149[Z_{-24}(30)] + 1.2553[Z_0(30)] + 1.6675[T_0(30)]$

$T_0(10) = - 362.25 + 0.32749[T_{-24}(10)] + 0.12627[Z_0(10)] - 0.12627[Z_0(30)] - 0.90762[T_0(30)] + 0.134645[T_{-24}(50)] + 0.134645[T_{-24}(50)]$

2 $Z_0(10) = 1674.8 + 0.63275[Z_{-24}(10)] - 1.23019[Z_{-24}(30)] + 0.50501[Z_{-24}(50)]$

$T_0(10) = - 355.12 + 0.11963[Z_0(10)] - 0.11963[Z_0(30)] - 0.32729[T_0(50)] - 0.32729[T_0(30)] + 0.19539[T_{-24}(10)]$

3 $Z_0(10) = 972.6 + 0.442812[Z_{-24}(10)] - 0.42673[Z_{-24}(30)] + 1.0625[Z_0(30)] + 5.4235[T_0(30)]$

$T_0(10) = - 415.4 + 0.14216[Z_0(10)] - 0.14216[Z_0(30)] - 0.76711[T_0(30)] + 0.16145[T_{-24})]$

Band	Predictand
4	$Z_0(10) = 1610.1 + 0.68338[Z_0(30)] + 0.55262[Z_0(50)] + 10.797[T_0(30)] + 0.0053834[Z_{-24}(10)]$
	$T_0(10) = -266.72 + 0.091752[Z_0(10)] - 0.091752[Z_0(30)] + 0.39929[T_{-24}(10)] - 0.41496[T_{-24}(30)]$
5	$Z_0(10) = 886.81 + 1.0927[Z_0(30)] + 0.71701[Z_{-24}(10)] - 1.38211[Z_{-24}(30)] + 0.6651[Z_{-24}(50)] + 4.4486[T_0(30)]$
	$T_0(10) = -246.59 + 0.085166[Z_0(10)] - 0.085166[Z_0(30)] + 0.40911[T_{-24}(10)] - 0.34129[T_{-24}(30)]$
6	$Z_0(10) = 885.69 + 1.1247[Z_0(30)] + 0.63856[Z_{-24}(10)] - 1.29971[Z_{-24}(30)] + 0.66115[Z_{-24}(50)] + 5.669[T_0(30)]$
	$T_0(10) = -353.9 + 0.12455[Z_0(10)] - 0.12455[Z_0(30)] - 0.38547[T_0(30)] + 0.12583[T_{-24}(10)]$
7	$Z_0(10) = 1026.5 + 1.1026[Z_0(30)] + 0.61638[Z_{-24}(10)] - 1.32284[Z_{-24}(30)] + 0.70646[Z_{-24}(50)] + 3.1769[T_0(30)]$
	$T_o(10) = -313.1 + 0.11098[Z_0(10)] - 0.11098[Z_0(30)] + 0.25109[T_{-24}(10)] - 0.146025[T_{-24}(50)] - 0.146025[T_{-24}(30)]$
8	$Z_0(10) = 1098.2 + 1.1661[Z_0(30)] + 0.94071[Z_{-24}(10)] - 0.94071[Z_{-24}(30)] + 2.2762[T_0(30)] - 0.20941[T_{-24}(10)]$
	$T_0(10) = -274.55 + 0.094757[Z_0(10)] - 0.094757[Z_0(30)] + 0.34467[T_{-24}(10)] - 0.18674[T_{-24}(50)] - 0.18674[T_{-24}(30)]$

14. Present Data—October, November

Band	Predictand
1	$Z_0(10) = 5207.3 - 0.46681[Z_0(30)] + 1.3974(Z_0(50)] + 15.844[T_0(30)]$
	$T_0(10) = -483.98 + 0.16642[Z_0(10)] - 0.16642[Z_0(30)] - 0.83989[T_0(30)]$
2	$Z_0(10) = 2554.1 + 1.0316[Z_0(30)] + 8.9399[T_0(30)]$
	$T_0(10) = -460.49 + 0.15823[Z_0(10)] - 0.15823[Z_0(30)] - 0.75149[T_0(30)]$

Band Predictand

3 $Z_0(10) = 1989.0 + 1.0991(Z_0(30)] + 8.0509[T_0(30)]$

$T_0(10) = -477.94 + 0.16425[Z_0(10)] - 0.16425[Z_0(30)] - 0.81825[T_0(30)]$

4 $Z_0(10) = 983.76 + 1.2311[Z_0(30)] + 8.454[T_0(30)]$

$T_0(10) = -376.87 + 0.12936[Z_0(10)] - 0.12936[Z_0(30)] - 0.22831[T_0(50)] - 0.22831[T_0(30)]$

5 $Z_0(10) = 960.36 + 0.50637[Z_0(30)] + 0.85363[Z_0(50)] + 9.6107[T_0(30)]$

$T_0(10) = -362.10 + 0.1261[Z_0(10)] - 0.1261[Z_0(30)] - 0.34441[T_0(30)]$

6 $Z_0(10) = 1235.6 + 1.2104[Z_0(30)] + 9.7816[T_0(30)]$

$T_0(10) = -416.02 + 0.14546[Z_0(10)] - 0.14546[Z_0(30)] - 0.51329[T_0(30)]$

7 $Z_0(10) = 2245.9 + 1.0473[Z_0(30)] + 4.3796[T_0(30)]$

$T_0(10) = -388.93 + 0.13769[Z_0(10)] - 0.13769[Z_0(30)] - 0.33907[T_0(30)]$

8 $Z_0(10) = 1627.9 + 1.1327[Z_0(30)] + 5.5417[T_0(30)]$

$T_0(10) = -290.6 + 0.13959[Z_0(10)] - 0.153136[Z_0(30)] - 0.193975[T_0(50)] - 0.193975[T_0(30)]$

15. Past and Present Data—Warming: January, February '63

Band Predictand

W $Z_0(10) = 2302.4 + 0.6955[Z_{-25}(10)] - 1.8019[Z_{-24}(30)] + 1.8019[Z_{-24}(50)] + 7.6937[T_0(30)] + 0.4040[Z_0(30)]$

$T_0(10) = -414.10 + 0.1219[T_{-24}(10)] + 0.1397[Z_0(10)] - 0.1397[Z_0(30)] - 0.8183[T_0(30)]$

16. Present Data—Warming: January, February '63

Band Predictand

W $Z_0(10) = 6437.3 + 8.7449[T_0(30)] + 0.5339[Z_0(30)]$

$T_0(10) = -473.6 + 0.1590[Z_0(10)] - 0.1590[Z_0(30)] - 0.9808[T_0(30)]$

APPENDIX II

RESULTS USING
TRC VERTICAL EXTRAPOLATION EQUATIONS
FOR SPECIFYING 10-mb HEIGHTS AND TEMPERATURES

(Independent and Dependent Data)

TABLE XIV

DECEMBER, JANUARY, FEBRUARY

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
2A	$Z_0(10)$	$Z_{-24}(10)$, $T_0(30)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $H_{-24}(50\text{-}30)$	362	39	201 ft	163 ft	1255 ft	1148 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$	362	39	2.4°C	2.0°C	8.5°C	9.2°C
4A	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$	320	34	214 ft	189 ft	863 ft	1031 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24(10)}$	320	34	2.3°C	2.6°C	6.0°C	7.1°C
5	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$	1325	68	165 ft	177 ft	666 ft	704 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	1325	68	2.4°C	2.6°C	4.9°C	6.0°C
6	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$	238	25	192 ft	176 ft	756 ft	750 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$	238	25	2.4°C	2.3°C	6.1°C	5.3°C
7	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$	693	75	167 ft	168 ft	421 ft	388 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	693	75	2.6°C	2.2°C	3.7°C	4.0°C
8	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$	640	69	154 ft	145 ft	451 ft	424 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	640	69	2.3°C	2.5°C	4.2°C	4.5°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XIV

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	122	11	292 ft	322 ft	1159 ft	1036 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(50-30)$	122	11	$2.0^\circ C$	$1.9^\circ C$	$8.3^\circ C$	$8.8^\circ C$
2	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	853	92	296 ft	333 ft	1279 ft	1322 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	853	92	$2.5^\circ C$	$2.5^\circ C$	$8.4^\circ C$	$9.7^\circ C$
4A	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	889	96	322 ft	294 ft	894 ft	983 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	889	96	$2.7^\circ C$	$2.9^\circ C$	$6.4^\circ C$	$6.5^\circ C$
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	3111	161	282 ft	296 ft	691 ft	687 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$	3111	161	$2.9^\circ C$	$2.6^\circ C$	$5.3^\circ C$	$5.4^\circ C$
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	664	72	335 ft	319 ft	736 ft	658 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	664	72	$2.8^\circ C$	$3.0^\circ C$	$6.5^\circ C$	$6.5^\circ C$
7	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	1153	125	227 ft	233 ft	461 ft	413 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	1153	125	$2.8^\circ C$	$2.5^\circ C$	$3.9^\circ C$	$4.0^\circ C$
8	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	1686	183	205 ft	246 ft	478 ft	431 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	1686	183	$2.7^\circ C$	$2.7^\circ C$	$4.3^\circ C$	$4.5^\circ C$

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XV
MARCH

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$T_0(30)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $H_{-24}(50\text{-}30)$	40	-	158 ft	-	1773 ft	-
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $Z_0(30)$, $\overline{T}_{-24}(50\text{-}30)$	40	-	2.1°C	-	13.8°C	-
2	$Z_0(10)$	$H_0(50\text{-}30)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $H_{-24}(50\text{-}30)$, $T_0(30)$	170	18	154 ft	179 ft	1459 ft	1600 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $\overline{T}_{-24}(50\text{-}30)$	170	18	1.7°C	1.6°C	8.0°C	10.3°C
3	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $T_0(30)$, $H_{-24}(30\text{-}10)$	116	12	166 ft	148 ft	1070 ft	1291 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $\overline{T}_{-24}(50\text{-}30)$, $\overline{T}_{-24}(10)$	116	12	1.9°C	1.5°C	7.1°C	6.6°C
4	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(10)$, $H_{-24}(30\text{-}10)$, $T_0(30)$	246	27	159 ft	143 ft	800 ft	786 ft
	$T_0(10)$	$T_{-24}(10)$, $H_0(30\text{-}10)$, $\overline{T}_{-24}(30\text{-}10)$	246	27	2.1°C	1.7°C	5.1°C	3.9°C
5	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$	685	36	141 ft	110 ft	659 ft	610 ft
	$T_0(10)$	$T_{-24}(10)$, $H_0(30\text{-}10)$, $\overline{T}_0(50\text{-}30)$, $\overline{T}_{-24}(30\text{-}10)$	685	36	2.2°C	2.4°C	4.7°C	4.3°C
6	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$	162	18	161 ft	118 ft	566 ft	601 ft
	$T_0(10)$	$T_{-24}(10)$, $H_0(30\text{-}10)$, $\overline{T}_{-24}(30\text{-}10)$, $Z_0(30)$	162	18	2.4°C	2.2°C	5.3°C	5.9°C
7	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$	288	31	159 ft	120 ft	306 ft	320 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$, $\overline{T}_0(50\text{-}30)$	288	31	2.3°C	2.9°C	3.3°C	3.4°C
8	$Z_0(10)$	$Z_{-24}(10)$, $T_0(30)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $H_{-24}(50\text{-}30)$	316	35	141 ft	149 ft	421 ft	376 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	316	35	2.1°C	1.9°C	4.4°C	4.2°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XV

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$T_0(30)$, $Z_0(30)$	99	9	283 ft	344 ft	1680 ft	1375 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	99	9	2.1°C	1.4°C	12.1°C	11.9°C
2	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	419	45	235 ft	223 ft	1443 ft	1435 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$, $T_0(30)$	419	45	1.8°C	2.1°C	8.5°C	9.0°C
3	$Z_0(10)$	$H_0(50-30)$, $Z_0(30)$, $T_0(30)$	273	29	229 ft	239 ft	1159 ft	1293 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	273	29	1.9°C	1.7°C	7.8°C	7.6°C
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	616	68	257 ft	239 ft	848 ft	806 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	616	68	2.3°C	1.7°C	5.1°C	4.4°C
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	1464	77	251 ft	235 ft	662 ft	631 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	1464	77	2.7°C	2.6°C	4.6°C	4.2°C
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	338	37	274 ft	257 ft	563 ft	637 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	338	37	2.5°C	2.5°C	5.4°C	5.6°C
7	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	484	52	188 ft	202 ft	324 ft	358 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	484	52	2.4°C	2.7°C	3.3°C	3.6°C
8	$Z_0(10)$	$T_0(30)$, $Z_0(30)$	723	80	220 ft	214 ft	418 ft	383 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	723	80	2.4°C	2.4°C	4.3°C	3.9°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XVI
APRIL

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_{-24}(10)$, $T_0(30)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$	94	10	148 ft	138 ft	1305 ft	1554 ft
	$T_0(10)$	$T_{-24}(10)$, $H_0(30\text{-}10)$, $T_0(30)$	94	10	2.0°C	1.6°C	7.2°C	7.1°C
2	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$	170	18	128 ft	105 ft	1280 ft	1490 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$	170	18	1.6°C	2.4°C	6.5°C	7.5°C
3	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$	108	11	125 ft	118 ft	981 ft	1155 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	108	11	1.7°C	1.7°C	5.4°C	6.0°C
4	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$, $H_0(50\text{-}30)$	265	29	134 ft	132 ft	676 ft	687 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$	265	29	1.9°C	1.8°C	3.7°C	3.9°C
5	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$	767	40	124 ft	134 ft	548 ft	489 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	767	40	1.8°C	1.7°C	4.5°C	4.1°C
6	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $H_{-24}(50\text{-}30)$	177	19	129 ft	146 ft	467 ft	478 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	177	19	1.9°C	2.1°C	4.2°C	4.1°C
7	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $Z_{-24}(10)$	335	37	153 ft	140 ft	353 ft	287 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$, $T_0(30)$	335	37	2.2°C	2.1°C	3.0°C	2.3°C
8	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30\text{-}10)$, $T_0(30)$, $Z_{-24}(10)$	356	39	142 ft	99 ft	453 ft	429 ft
	$T_0(10)$	$H_0(30\text{-}10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30\text{-}10)$	356	39	2.1°C	2.0°C	3.1°C	2.8°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XVI

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	220	24	240 ft	237 ft	1357 ft	1520 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	220	24	$2.0^{\circ}C$	$1.6^{\circ}C$	$7.1^{\circ}C$	$7.2^{\circ}C$
2	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	394	42	197 ft	247 ft	1263 ft	1298 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	394	42	$1.9^{\circ}C$	$2.2^{\circ}C$	$6.4^{\circ}C$	$7.1^{\circ}C$
3	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	247	26	168 ft	180 ft	972 ft	989 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	247	26	$1.7^{\circ}C$	$1.7^{\circ}C$	$5.5^{\circ}C$	$5.3^{\circ}C$
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	607	66	183 ft	165 ft	694 ft	711 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	607	66	$2.1^{\circ}C$	$1.8^{\circ}C$	$3.8^{\circ}C$	$3.9^{\circ}C$
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	1489	78	221 ft	217 ft	560 ft	474 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $Z_0(30)$	1489	78	$2.1^{\circ}C$	$2.0^{\circ}C$	$4.5^{\circ}C$	$4.2^{\circ}C$
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	365	39	203 ft	239 ft	493 ft	475 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	365	39	$2.2^{\circ}C$	$2.2^{\circ}C$	$4.3^{\circ}C$	$4.9^{\circ}C$
7	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	526	58	182 ft	142 ft	369 ft	296 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	526	58	$2.1^{\circ}C$	$2.1^{\circ}C$	$3.0^{\circ}C$	$2.7^{\circ}C$
8	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	732	80	189 ft	171 ft	451 ft	447 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	732	80	$2.3^{\circ}C$	$2.2^{\circ}C$	$3.2^{\circ}C$	$3.0^{\circ}C$

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XVII

MAY

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $H_{-24}(50-30)$, $H_0(50-30)$	120	13	122 ft	101 ft	696 ft	733 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$	120	13	1.4°C	1.4°C	3.7°C	3.5°C
2	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $Z_{-24}(10)$	86	9	135 ft	152 ft	658 ft	582 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $\overline{T}_0(50-30)$	86	9	1.4°C	1.7°C	3.4°C	3.1°C
3	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$	50	-	131 ft	-	401 ft	-
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $\overline{T}_0(50-30)$	50	-	1.3°C	-	3.6°C	-
4	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$, $H_0(50-30)$	161	16	149 ft	125 ft	453 ft	329 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $\overline{T}_{-24}(50-30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$	161	16	1.8°C	2.0°C	4.1°C	3.4°C
5	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	377	19	123 ft	118 ft	424 ft	430 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$	377	19	1.9°C	1.7°C	3.7°C	4.1°C
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $H_{-24}(50-30)$	176	19	143 ft	125 ft	425 ft	414 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $\overline{T}_0(50-30)$, $T_{-24}(10)$	176	19	1.8°C	1.5°C	3.3°C	3.2°C
7	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$	380	42	147 ft	147 ft	398 ft	290 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_{-24}(10)$	380	42	2.1°C	2.6°C	2.9°C	3.3°C
8	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	232	25	127 ft	134 ft	378 ft	340 ft
	$T_0(10)$	$H_0(30-10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$, $T_0(30)$	232	25	2.0°C	1.5°C	3.0°C	2.3°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XVII

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	252	27	167 ft	157 ft	711 ft	627 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	252	27	1.5°C	1.9°C	4.1°C	3.6°C
2	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	212	22	194 ft	210 ft	653 ft	556 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	212	22	1.6°C	1.5°C	3.6°C	3.8°C
3	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	132	14	164 ft	156 ft	527 ft	615 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	132	14	1.7°C	1.4°C	3.7°C	3.8°C
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	375	40	199 ft	194 ft	478 ft	395 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	375	40	1.9°C	1.9°C	4.0°C	3.7°C
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	798	41	165 ft	159 ft	446 ft	397 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	798	41	2.0°C	1.9°C	3.6°C	3.7°C
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	376	41	159 ft	191 ft	435 ft	438 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $\overline{T}_0(50-30)$	376	41	2.0°C	1.8°C	3.3°C	3.0°C
7	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	585	64	170 ft	163 ft	409 ft	331 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$	585	64	2.1°C	2.5°C	3.0°C	3.6°C
8	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	528	57	199 ft	183 ft	424 ft	353 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$	528	57	2.1°C	1.8°C	3.1°C	2.4°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XVIII

JUNE, JULY, 1/2 AUGUST (1-15)

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	250	26	115 ft	94 ft	470 ft	399 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$	250	26	1.4°C	1.7°C	3.1°C	2.9°C
2	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	190	20	114 ft	131 ft	528 ft	452 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$	190	20	1.5°C	2.0°C	2.8°C	3.4°C
3	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $H_{-24}(50-30)$, $H_0(50-30)$	137	13	121 ft	102 ft	544 ft	511 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$, $T_0(30)$	137	13	1.5°C	1.6°C	2.6°C	2.3°C
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $Z_{-24}(10)$	410	44	107 ft	120 ft	445 ft	465 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_0(30)$, $\overline{T}_0(50-30)$	410	44	1.6°C	1.4°C	2.7°C	2.9°C
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $Z_{-24}(10)$	869	44	119 ft	116 ft	450 ft	490 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_{-24}(10)$	869	44	1.8°C	1.6°C	2.7°C	2.6°C
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $Z_{-24}(10)$	415	46	112 ft	142 ft	484 ft	482 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $Z_0(30)$	415	46	1.6°C	1.8°C	2.8°C	3.0°C
7	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$	697	76	138 ft	142 ft	507 ft	464 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_{-24}(10)$	697	76	2.1°C	2.0°C	2.8°C	2.7°C
8	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $H_0(50-30)$	581	64	155 ft	156 ft	466 ft	438 ft
	$T_0(10)$	$H_0(30-10)$, $T_{-24}(10)$, $T_0(30)$	581	64	2.1°C	2.0°C	3.0°C	2.8°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XVIII

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	596	63	159 ft	116 ft	480 ft	404 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	596	63	1.6°C	1.6°C	3.1°C	2.7°C
2	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	515	55	160 ft	161 ft	534 ft	542 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$	515	55	1.6°C	1.7°C	2.9°C	3.4°C
3	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	322	33	140 ft	111 ft	539 ft	484 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$	322	33	1.6°C	1.3°C	2.9°C	2.2°C
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	1043	113	151 ft	171 ft	505 ft	462 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_0(30)$	1043	113	1.8°C	1.8°C	2.9°C	3.2°C
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	2014	103	165 ft	135 ft	525 ft	519 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $\overline{T}_0(50-30)$	2014	103	1.9°C	1.8°C	2.9°C	2.6°C
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	900	97	132 ft	142 ft	501 ft	443 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_0(30)$	900	97	1.7°C	1.8°C	2.9°C	3.0°C
7	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	1189	129	193 ft	149 ft	523 ft	491 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_0(30)$	1189	129	2.3°C	1.9°C	3.0°C	2.6°C
8	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	1324	145	167 ft	164 ft	503 ft	466 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$	1324	145	2.2°C	2.1°C	3.0°C	3.0°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XIX
1/2 AUGUST (16-31), SEPTEMBER

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	112	12	96 ft	79 ft	990 ft	898 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(50-30)$	112	12	1.1°C	1.2°C	4.3°C	4.2°C
2	$Z_0(10)$	$Z_{-24}(10)$, $T_0(30)$, $H_{-24}(30-10)$, $T_0(30)$	96	9	95 ft	116 ft	872 ft	672 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$	96	9	1.4°C	1.1°C	4.5°C	3.4°C
3	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$	67	-	105 ft	-	585 ft	-
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$	67	-	1.5°C	-	3.4°C	-
4	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	228	24	132 ft	122 ft	644 ft	602 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$	228	24	1.7°C	1.4°C	3.9°C	4.1°C
5	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$, $H_0(50-30)$	546	28	117 ft	134 ft	452 ft	419 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_{-24}(50-30)$, $T_{-24}(10)$	546	28	1.9°C	1.9°C	3.0°C	2.8°C
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $H_{-24}(50-30)$, $H_0(50-30)$	215	23	101 ft	156 ft	442 ft	515 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$	215	23	1.7°C	2.7°C	3.0°C	4.3°C
7	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$	342	37	142 ft	158 ft	490 ft	543 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$	342	37	2.1°C	2.1°C	3.0°C	2.7°C
8	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $Z_{-24}(10)$, $T_0(30)$	363	40	128 ft	138 ft	433 ft	418 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$, $T_{-24}(10)$	363	40	2.4°C	2.3°C	3.2°C	3.8°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XIX

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	300	32	159 ft	148 ft	1046 ft	1102 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $Z_0(30)$	300	32	$1.6^\circ C$	$1.5^\circ C$	$4.6^\circ C$	$5.4^\circ C$
2	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	328	33	168 ft	174 ft	902 ft	788 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$, $T_0(30)$	328	33	$1.7^\circ C$	$1.0^\circ C$	$4.5^\circ C$	$3.7^\circ C$
3	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	189	19	157 ft	147 ft	621 ft	560 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	189	19	$1.5^\circ C$	$1.7^\circ C$	$3.7^\circ C$	$3.2^\circ C$
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	594	64	166 ft	131 ft	652 ft	626 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	594	64	$1.7^\circ C$	$1.5^\circ C$	$3.8^\circ C$	$3.7^\circ C$
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	1267	65	149 ft	159 ft	495 ft	417 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$	1267	65	$1.9^\circ C$	$1.9^\circ C$	$2.9^\circ C$	$2.7^\circ C$
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	491	52	127 ft	194 ft	488 ft	442 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	491	52	$1.7^\circ C$	$2.3^\circ C$	$3.0^\circ C$	$3.5^\circ C$
7	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	586	63	178 ft	169 ft	517 ft	501 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$	586	63	$2.5^\circ C$	$2.4^\circ C$	$3.2^\circ C$	$2.8^\circ C$
8	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	859	95	138 ft	169 ft	453 ft	419 ft
	$T_0(10)$	$H_0(30-10)$, $Z_0(30)$	859	95	$2.2^\circ C$	$2.3^\circ C$	$3.0^\circ C$	$3.3^\circ C$

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XX

OCTOBER, NOVEMBER

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$	28	-	107 ft	-	779 ft	-
	$T_0(10)$	$T_{-24}(10)$, $H_0(30-10)$, $T_0(30)$, $\overline{T}_{-24}(50-30)$	28	-	1.2°C	-	4.7°C	-
2	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$, $H_{-24}(50-30)$	153	17	130 ft	103 ft	812 ft	788 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$, $T_{-24}(10)$	153	17	1.8°C	2.0°C	4.5°C	5.0°C
3	$Z_0(10)$	$Z_{-24}(10)$, $Z_0(30)$, $T_0(30)$, $H_{-24}(30-10)$	126	13	126 ft	124 ft	743 ft	942 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$	126	13	2.0°C	1.5°C	4.4°C	3.6°C
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$, $Z_{-24}(10)$	211	22	139 ft	176 ft	732 ft	722 ft
	$T_0(10)$	$H_0(30-10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$	211	22	1.7°C	1.6°C	4.7°C	4.9°C
5	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	661	33	133 ft	121 ft	666 ft	747 ft
	$T_0(10)$	$H_0(30-10)$, $T_{-24}(10)$, $\overline{T}_{-24}(30-10)$	661	33	1.8°C	1.6°C	4.3°C	4.7°C
6	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	187	20	120 ft	151 ft	656 ft	721 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$, $T_{-24}(10)$	187	20	1.9°C	1.8°C	4.6°C	5.6°C
7	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $H_{-24}(50-30)$	486	53	146 ft	129 ft	395 ft	404 ft
	$T_0(10)$	$H_0(30-10)$, $T_{-24}(10)$, $\overline{T}_{-24}(50-30)$	486	53	2.4°C	2.2°C	3.8°C	3.2°C
8	$Z_0(10)$	$Z_0(30)$, $H_{-24}(30-10)$, $T_0(30)$, $T_{-24}(10)$	337	37	129 ft	134 ft	472 ft	438 ft
	$T_0(10)$	$H_0(30-10)$, $T_{-24}(10)$, $\overline{T}_{-24}(50-30)$	337	37	2.1°C	1.9°C	3.8°C	3.1°C

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XX

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	105	10	189 ft	187 ft	902 ft	786 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	105	10	1.3^oC	2.1^oC	5.1^oC	4.4^oC
2	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	497	53	218 ft	216 ft	876 ft	977 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	497	53	2.0^oC	1.6^oC	5.0^oC	5.6^oC
3	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	363	38	217 ft	238 ft	750 ft	683 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	363	38	2.2^oC	1.5^oC	4.9^oC	4.5^oC
4	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	650	70	230 ft	224 ft	786 ft	729 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$	650	70	1.9^oC	1.9^oC	4.8^oC	5.3^oC
5	$Z_0(10)$	$Z_0(30)$, $T_0(30)$, $H_0(50-30)$	1011	88	167 ft	204 ft	694 ft	688 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	1011	88	2.1^oC	1.8^oC	4.3^oC	4.2^oC
6	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	481	51	217 ft	257 ft	771 ft	794 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	481	51	2.1^oC	1.8^oC	5.3^oC	6.2^oC
7	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	843	92	182 ft	194 ft	417 ft	429 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	843	92	2.6^oC	2.4^oC	3.6^oC	3.7^oC
8	$Z_0(10)$	$Z_0(30)$, $T_0(30)$	972	107	208 ft	219 ft	486 ft	501 ft
	$T_0(10)$	$H_0(30-10)$, $\overline{T}_0(50-30)$, $Z_0(30)$	972	107	2.4^oC	2.2^oC	3.9^oC	3.9^oC

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XXI

WARMING – JANUARY, FEBRUARY, 1963

(a) Past and Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1-4	$Z_0(10)$	$Z_{-24}(10)$, $H_{-24}(50\text{-}30)$, $T_0(30)$, $Z_0(30)$	36	-	384 ft	-	1138 ft	-
	$T_0(10)$	$T_{-24}(10)$, $H_0(30\text{-}10)$, $T_0(30)$	36	-	$3.8^\circ C$	-	$12.9^\circ C$	-

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

TABLE XXI

(b) Present Data

Band	Specificand	Selected specifiers*	No. of cases		Rms error		Std. dev.	
			Dep.	Ind.	Dep.	Ind.	Dep.	Ind.
1-4	$Z_0(10)$	$T_0(30)$, $Z_0(30)$	120	13	639 ft	395 ft	1227 ft	1002 ft
	$T_0(10)$	$H_0(30-10)$, $T_0(30)$	120	13	$4.7^{o}C$	$2.8^{o}C$	$12.0^{o}C$	$9.1^{o}C$

*Listed in order of selection. H is thickness, Z is height, T is temperature and $\overline{T}$ is the average temperature between two constant pressure surfaces. Subscript 0 indicates observation time and subscript -24 indicates 24 hrs before observation time.

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Two sets of vertical extrapolation equations were derived to specify initial-guess fields of 10-mb heights and temperatures using a five-year data sample.

Both past (t_{-24}) and present (t_0) data were considered as specifiers in the first set of equations. Only present (t_0) data were used as specifiers in the second set of equations. Both sets of equations showed stability when tested on independent data. Further, verification statistics showed that the results from the independent data were similar to those from the dependent data.

Both sets of equations were then compared by incorporating them into a modified successive approximation technique to produce initial-guess fields. These initial-guess fields were similar. An experiment comparing the two sets of equations with equations derived by the U.S. Weather Bureau showed that the TRC equations gave lower specification errors.

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